



# MUSICAL SERENDIPITY

Aalto University  
publication series  
DOCTORAL  
DISSERTATIONS  
2/2018

School of Arts, Design and Architecture  
Aalto ARTS Books  
Helsinki  
[shop.aalto.fi](http://shop.aalto.fi)

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Design Merkitys / Safa Hovinen  
Materials Munken Lynx 120 & 300 g/m<sup>2</sup>  
Fonts Eurostile & Warnock

ISBN 978-952-60-7741-3  
ISSN 1799-4934

Printed by Aldus Oy, Finland  
2017

MUSICAL SEERENZO  
PARTY



# MUSICAL SERENDIPITY

*Designing for  
Contextual Music  
Recommendation  
and Discovery*

PIRKKKA ÅMAN

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# ABSTRACT

Online media services with recommendation facilities provide the users with a possibility to tailor the recommended content such as books, TV series and music to the users' personal preferences. Online music recommendation services are a subset of personalizable media services. As music preferences vary greatly across music listening situations, information about the user's situation, in other words, context information, is sometimes involved in modern music recommendation services.

In this thesis, I suggest new ways of including context information, mainly location, to interactive music recommendations by presenting various concepts and prototypes. In the articles, I presented two prototypes, Sounds of Helsinki (Article II) and OUTmedia (Article IV), as well as a platform for several context-aware music service concepts (Article III). Furthermore, two articles reviewed the existing music services for their explanations and transparency (Article I) and the ways they involved context factors in interacting with music recommendation and discovery tasks (Article V).

The underlying argument and a starting point for the thesis was that by involving context factors, ultimately cultural diversity could be fostered. In an ideal case, adding *context* to music recommendations would lead to recommendations that offer more *non-mainstream* music than channels such as the playlist radio or playlists of new releases of online music services. That would lead to better chances for *serendipitous discoveries*, and, ultimately, given that the user base would be large enough, would promote *cultural diversity* as well.

While the results show that the users indeed experienced serendipity in many ways, in the light of the results it can not be proven that context-aware music recommendations necessarily lead to cultural diversity. In addition, the results can not be generalized to all context-aware music recommendation cases. Instead, design implications are given to help designers and researchers of future systems to build rewarding and enjoyable context-aware content services, especially to enrich urban environments. The implications include *Supporting open meaning-making* through combinations of different media content and places; *Visual and interactive UI elements* that communicate the system logic or explain why a recommendation was made; *Positive*

*restrictions*, such as allowing the content to be available only when the user is near a certain location or within a defined time window; *Supporting serendipity* can be approached in many ways, for example by combining music with an activity, a location, certain time or an identity, which may result in serendipitous discoveries of not only music but the cultural layers of urban environments as well.

### **Keywords and phrases**

Music recommendation, music discovery, urban computing, context-awareness, context-aware music services, serendipity, urban augmentation, location-awareness, mobile computing, pervasive computing, ubiquitous computing, field studies.

# ACKNOWLEDGEMENTS

First of all, I am extremely grateful to my supervisor Lassi A. Liikkanen, who has guided me, providing the possibility to conduct research on topics that are both academically relevant and personally interesting. I can not imagine this work being realized as it is without his guidance.

I thank all my former colleagues at Helsinki Institute for Information Technology HIIT, of whom specifically Petteri Nurmi, Andreas Forsblom and Atte Hinkka have played an important part in the research towards this thesis.

Of the former and present people at my alma mater, Media Lab Helsinki at Aalto University's School of Arts, Design and Architecture, I specifically wish to thank professor Lily Diaz-Kommonen, who has provided me with an immeasurable support through the years, together with Antti Ikonen, Teemu Leinonen, Philip Dean, Matti Arvilommi, Mauri Kaipainen, Kari-Hans Kommonen, Raimo Lång and Hanna Holm. The whole Media Lab Helsinki community with its eclectic, smart and friendly people has been incredible over the years.

My former colleagues at Think Tank Demos Helsinki provided me with immersion into an efficient approach to co-design and collaboration and edified my understanding about societal issues. Thanks to Roope Mokka, Aleksi Neuvonen, Outi Kuittinen, Tuuli Kaskinen, Tommi Laitio and Olli Alanen for that.

I am grateful to my pre-examiners Dr. Jeni Paay and Dr. Markus Shedl for their comments and suggestions. I thank everyone else who has given me advice and feedback on my work, as well as numerous anonymous referees. I also thank the colleagues with whom I have co-authored papers during the past few years.

Finally, I am eternally grateful to my beloved parents Pirjo and Pentti and my brother Arhippa, who have supported and encouraged me in my studies and made everything possible.





# ORIGINAL PUBLICATIONS

The thesis is based on the following original publications, which are referred to in the text as Articles I–V. The articles are reprinted at the end of the thesis.

## Article I

Åman, P., & Liikkanen, L. A. (2010). A survey of music recommendation aids. *CEUR Workshop Proceedings* (Vol. 633, pp. 25–28).

## Article II

Forsblom, A., Nurmi, P., Åman, P., & Liikkanen, L. A. (2012). Out of the bubble – Serendipitous event recommendations at an urban culture festival. *International Conference on Intelligent User Interfaces, Proceedings*, 253–256.

## Article III

Åman, P., & Liikkanen, L. A. (2013). Painting the city with music: Context-aware mobile services for urban environment. *Continuum*, 27(4), 542–557.

## Article IV

Åman, P., Liikkanen, L. A., & Hinkka, A. (2015). Enriching user experiences with location-sensitive music services. *Journal of Location Based Services*, 9(3), 167–186.

## Article V

Åman, P., & Liikkanen, L. A. (2016). Interacting with context factors in music recommendation and discovery. *International Journal of Human-computer Interaction*, 33(3), 165–179.

# AUTHOR'S CONTRIBUTION

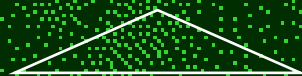
Articles I and V present expert reviews and analyses of the existing commercial services and research prototypes, the former on the commercial music services and their recommendation facilities and the latter on the research prototypes of contextual music recommendation and discovery.

Article III suggests a framework for building contextual music services for urban environments. Articles II and IV introduce research prototypes of contextual music recommendation and discovery and report the field studies on the user experience of the prototypes.

All articles are joint work. In Articles I, III and V, I was the first writer and principal designer and researcher while Dr. Liikkanen supervised the process. In Article II, I was the concept designer and ran the field studies, while the first writer of the article was Andreas Forsblom, who also developed the software, Dr. Nurmi and Dr. Liikkanen supervising the process. In Article IV, I was the first writer and co-designer for the service concept as well as the main designer for the user interface, while Dr. Liikkanen supervised the process and Atte Hinkka developed the software.

\*

# 1 INTRODUCTION



**D**uring the past decade, the potential of networked digital media as envisioned by forerunners such as Weiser (1991) and Negroponte (1995) has started to realize. Time and location-independent production, distribution and consumption of media content, together with online social participation are now commonplace for everyone with a mobile computing device and Internet connection. This socio-technological revolution has also brought millions of music tracks available online through services such as YouTube, Spotify and Pandora. However, the overwhelming variety of music tracks available makes finding new, interesting music often burdensome. To overcome the paradox of choice (Schwartz, 2004), automated recommendation techniques and personalized filters have been introduced to help the decision-making process (Celma, 2010; Ricci, Rokach, Shapira, & Kantor, 2015).

Since personal music preferences vary across different situations, information describing the user's situation has recently been included in the recommendation process. The focus of this thesis is to suggest strategies for designing rewarding user interactions for music recommendation and discovery by applying contextual information, in other words, information regarding the user's situation.

This dissertation belongs to the field of *human-computer interaction* (HCI), which traditionally facilitates the design of interactive computer systems to be effective, efficient, easy, and enjoyable to use (Dix, Finlay, Abowd, & Beale 2003), and within HCI, to the *interaction design research*, which typically studies the interactions between people and computational applications such as mobile apps and web services (Fällman, 2011).

In the next paragraphs, I present the central concepts and themes addressed throughout the work and framing it, and at the end of the chapter, outline the structure of the thesis.

## 1.1 Key concepts and themes

*Personalization* refers to tailoring media content according to the user's preferences. *Recommendation systems* are an instance of personalization, implemented in applications such as online dating and travel systems either by gathering information from the user automatically or by user input. *Music interaction* refers to the human-technology interactions with recorded music content.

By dictionary definition, *serendipity* refers to “the faculty or phenomenon of finding valuable or agreeable things not sought for” (Merriam-Webster, 2016). In recommendation systems research, a recommended item is serendipitous if it is both *unfamiliar to the user* and *perceived as relevant* (i.e. good) (Castells, Hurley, & Vargas, 2015). I will use this definition throughout the thesis. For an example of what counts as serendipity, Apple's iPod Shuffle music player plays music from the user's music library in a random order, however, not presenting a case of true serendipity since the music tracks are already familiar. On the other hand, discovering an unfamiliar artist whose music matches the user's personal preferences serves as an example of a true case of serendipity. By the definition presented above, the dimension of *discovery* (as unfamiliarity) is contained in serendipity while the element of *surprise* is not. However, the element of surprise is often experienced together with serendipity. If the recommended item is perceived by a user also positively surprising, it may make an already positive experience of discovering something relevant and unfamiliar even better.

The concept of *context* refers to a certain frame within which something exists or happens (Adomavicius & Tuzhilin, 2015). The importance of the concept is highlighted by the ability of modern mobile phones to adapt to and offer services tailored to the user's situation, although currently in a much-constrained fashion. In this work, context is conceived of as four information types: location, time, activity and identity, of which the most common context factor applied so far is location (Adomavicius & Tuzhilin, 2015; Article V). The concept of context is discussed in detail in Chapter 2. Location-awareness, achieved by the global positioning system (GPS), wireless local area networks (WiFi), geolocation through Internet protocol address lookups, or radio signal measurement plays an important role in context-aware computing since it enables an accurate geographical positioning of mobile devices and their users. Indeed, positioning technologies

embedded in the modern mobile devices enabled the first context-aware computing applications (Want, Hopper, Falcao, & Gibbons, 1992).

UNESCO's declaration of *cultural diversity* states that cultural diversity is valuable as such, being as important to the cultures of the world as biodiversity is to the planet (UNESCO, 2001). Following the spirit of the declaration, promoting cultural diversity is the underlying ethical motif of this work. I have tried to promote it by introducing service concepts and prototypes for discovering not only music that is offered by mainstream channels such as playlist radio but also music chosen by other users or by the curators of an urban cultural festival aiming to promote a diverse set of artists.

Furthermore, I believe that by involving contextual information in music recommendation it is possible to promote serendipitous discoveries of unfamiliar music and by that, cultural diversity as well. This may happen for example by attaching music to places, as the relation between music and a place is often arbitrary, thus opening paths to potentially serendipitous discoveries through associative personal meaning-making processes constituted by interplay between music, places and other media content (Article IV). In other words, I believe that cultural diversity can, among other means, be promoted through contextual music recommendation and its potential for serendipity.

However, in the context of this thesis and the concepts (i.e. descriptions of music services and applications) and prototypes (i.e. working interactive applications) presented in the articles, it may be possible to show that the users experienced serendipity, while proving that cultural diversity was maintained or increased would require a much larger user base and potentially millions of users using contextual music services for long periods of time. Therefore, in the context of this work, cultural diversity must be seen as an ideal, an underlying goal that guided the design decisions.

Ideally, adding *context* to music recommendations would lead to recommendations that offer more *non-mainstream* music than channels such as the playlist radio or playlists of new releases of online music services. That would lead to better chances for *serendipitous discoveries*, and, ultimately, given that the user base would be large enough, would promote *cultural diversity* as well.

A resembling agenda is presented by Celma (2010). He argues that offering more non-mainstream recommendations may lead to increase in serendipitous discoveries. My addition is that beyond better recommendation algorithms, also adding context information to music recommendation may lead to increase in non-mainstream recommendations and to increase in



serendipitous discoveries. I will return to the argument and how it realized in my research in the concluding chapter (6).

Research on the individual and social uses of music (DeNora, 2000; Levitin, 2007) shows that *music preferences vary greatly across different situations*, be it physical conditions or social context. Therefore, context factors really should matter in designing interactive music services. The main motivation for developing and researching contextual music interactions and concepts stems from people having a wide variety of inter and intrapersonal uses and functions for music (van Goethem & Sloboda, 2011; Hargreaves & Hargreaves, 1999; North & Hargreaves, 1996). For example, self-regulation of mood is one of the most important functions of music in contemporary societies in terms of *psychological, individual use of music* (Hargreaves & Hargreaves, 1999). Most people are adept at choosing music to achieve certain personal emotional states. Music is specifically used for regulating personal energy levels for example in activities such as sports, studying, relaxing, working and various kinds of festivities. In the same vein, we can relieve anxiety by listening to calming music (Levitin, 2007; North & Hargreaves, 1996). As DeNora (1999, 32) puts it, by using music for self-regulation, it becomes a “technology of the self”.

One of the main *social functions* of music in modern societies is communication and building of one’s identity through music choices. Music is used as a means to integrate into or distance oneself from a cultural group, for example through the function of subcultures and the related identity building practices (DeNora, 1999; Hebdige, 1979). Music is an important part of the modern consumer culture and consumption choices are the main mode of communicating and building one’s identity in the post-industrial, westernized societies (DeNora, 1999). Recently, social media and its sharing, commenting and liking features have accelerated and expanded music-related social practices (Liikkanen & Salovaara, 2015).

In the pre-industrial societies, the socially cohesive rites and rituals of society – often having a religious dimension – were important occasions for music consumption (DeNora, 2000). While the social functions and needs remain the same, directly lived cultural forms have largely been replaced by mass-mediated forms such as “the society of spectacle”, discussed by Debord (1994). This is exemplified for instance by the hugely popular televised music format shows such as Idols and Voice of America.

With streaming services such as YouTube and Spotify, we have entered the era of *second generation of digital music services* where music can be

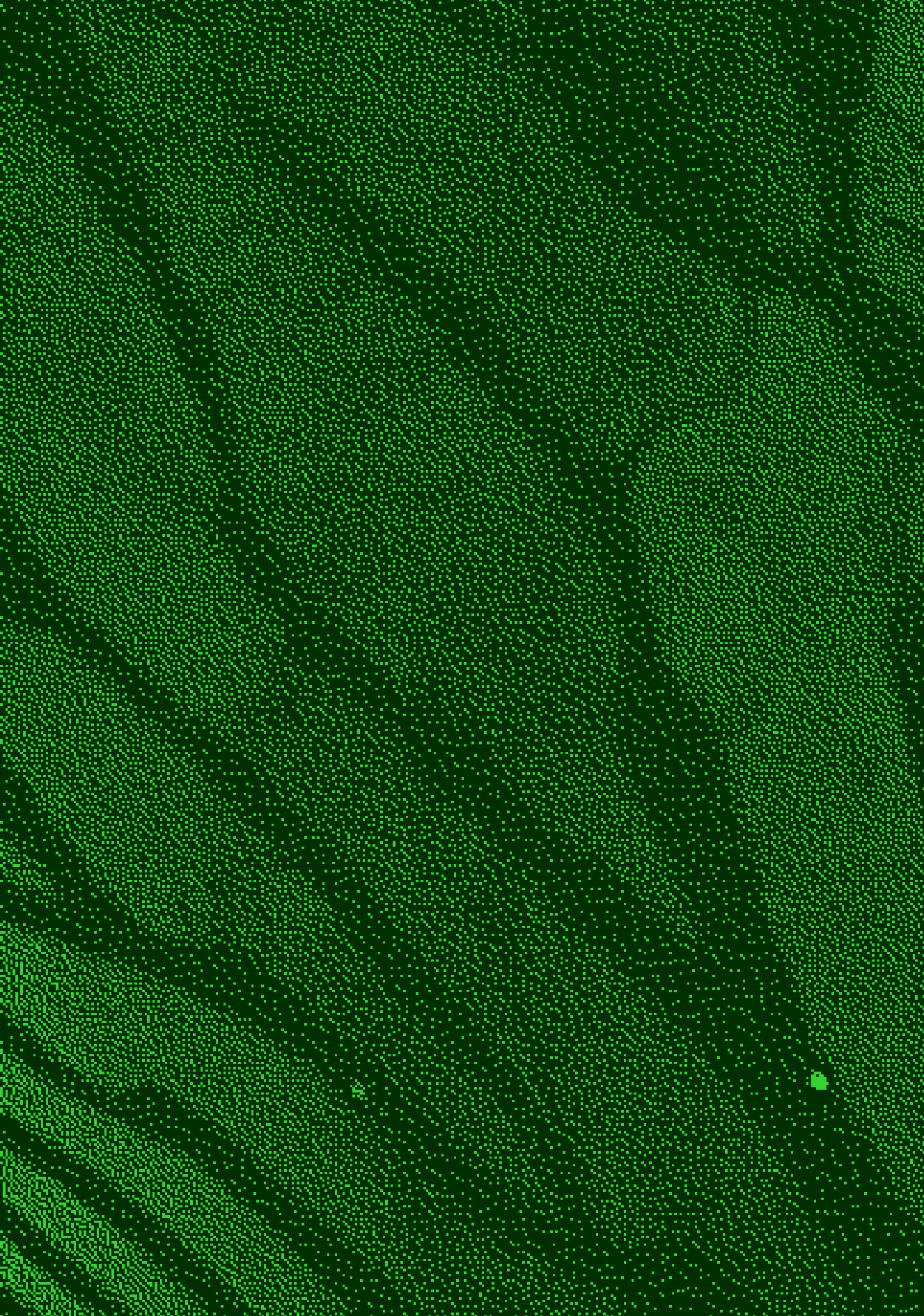
consumed as a stream over the Internet, without the ownership of an actual music file (Liikkanen & Åman, 2015). In most music consumption situations, the first generation physical discs or local music files are no longer needed. Today, *music is a truly ubiquitous commodity*; it can be listened to in almost any place or anytime with tens of millions of music tracks available on-demand, increasingly highlighting the importance of including context factors such as location, time and identity in music recommendation and discovery.

Through the two prototypes presented in the articles II and IV, I aimed at *augmenting urban environments* with a virtual, digital layer of music and other media. The first prototype, Sounds of Helsinki, applied a map interface, while the second one, OUTmedia was implemented as a mobile augmented reality (AR) application (for a demonstration see <https://goo.gl/S9px5U>). AR technology has been studied in academia for many years, but 2016 eventually saw the potential of mobile AR finally realizing by the first global killer mobile AR app Pokémon GO that reached a user base of hundreds of millions within a week from its roll-out (Allan, 2016).

## 1.2 Structure of the thesis

The next two chapters provide the theoretical background and review the relevant previous research on the topics of 1) the concept of context, and 2) music recommendation and discovery from the point of view of user interaction. Chapter 4 describes the design and research process of two prototypes for contextual music discovery that constituted an essential part of the research. It also presents the methods applied, the ways of user involvement, the design artifacts and the produced data. The contribution to the field follows in Chapter 5 by describing the key themes, findings and design implications. Finally, discussion and conclusions are presented in Chapter 6.

## INTRODUCTION



## **2** RESEARCH FRAMEWORK: THE CONCEPT OF CONTEXT



Context is studied by a wide variety of disciplines, each with their own respective definitions for the concept. It is central to several fields of research such as computer science (e.g. artificial intelligence, ubiquitous and context-aware computing), and cognitive science, design research, linguistics, philosophy, psychology and organizational sciences such as management studies (as discussed in Adomavicius & Tuzhilin, 2015; Bauer & Dey, 2016). In addition, even a conference series (International and Interdisciplinary Conference, CONTEXT) is dedicated to the concept and its use, extending to disciplines such as law, medicine and business. In this chapter, I examine the concept in regard to context-aware computing and e-commerce personalization (specifically music recommendation) within HCI and specifically interaction design research.

Generally, context is seen as *a framework wherein something occurs*. For example, in modern linguistics, a word acquires its meaning from the other words in a sentence, and other sentences surrounding it, that is, according to its context (Fiske, 1990). In HCI and design studies, the concept has grown ever more important since the mid-1990s when the mass adoption of personal, portable computing devices started. Up until that time, digital media was mainly consumed in stationary situations at home or in the workplace (Dey & Hakkila, 2008).

Modern mobile phones and tablets can typically measure up to twenty different types of information about the user and her situation (Vihavainen, 2013). Devices can also be used everywhere (ubiquitously), with an always-on connectivity and therefore they are able to exploit various situation-dependent information types to offer added value to the user. For example, an exercising app can show the user not only her location, but also consumed calories and distance covered. Compared with stationary use, mobile users interact with more devices, people and locations, making context-awareness vital for the designers of those systems.

Mobile and personal computing have spawned a number of terms, which highlight different aspects of interactions enabled by embedding

information technology to users' everyday lives. One of the most influential notions has been *ubiquitous computing*, coined by Weiser (1991), as a post-desktop, post “windows, icons, menus, pointer” (WIMP) model of human-computer interaction. Other terms referring to the closely related domains include *context-aware computing* (Schilit, Adams, & Want, 1994), *pervasive computing* (Ark and Selker, 1999), *embodied interaction* (Dourish, 2001; see 2.3), and *ambient intelligence* (Aarts, Harwig, & Schuurmans, 2001; Zelkha, Epstein, Birrell, & Dodsworth, 1998). In the next three sections, I present three different views on the concept of context.

## 2.1 Context as relevant information types

Context has been one of the central concepts in HCI since the mid-1990s when the development and adoption of portable media devices started to accelerate. In search and discovery tasks, context is “a necessary source of meaning” (Dervin, 2003). In the first HCI work using the term “context-aware”, Schilit and Theimer (1994) refer to context as “location, identities of nearby people and objects, and changes to those objects”. In their literature review of context within HCI, Dey and Abowd (1999) argue that previous definitions rely on giving synonyms or listing examples for context. For example, Franklin and Flaschbart (1998) define it as synonymous with a user's situation. Others, such as Brown, Bovey, and Chen (1997) and Ryan, Pascoe, and Morse (1997) list attributes such as the location of a user, the user's emotional state, time and weather as context. Listings or enumerations, however, are difficult to apply in practice since context, specifically in mobile situations, changes all the time. Therefore, Dey and Abowd (1999, 3–4) define context as follows:

Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves.

The definition is operational and directed to practical work by designers and developers in the field of context-aware computing. This definition helps to decide the factors that belong to the “context” of a particular application scenario. If a piece of information is relevant to interaction in that particular

use situation, it is part of the context. For example, in a mobile travel app for exploring the sights of a foreign city, location is relevant contextual information while the weather of the user's hometown is not. According to Dey and Abowd (1999), certain types of context are, in practice, more important than others. These primary context types are *location, identity, activity* and *time* (Figure 1). All the other (i.e. secondary) context types can be derived from these. For example, a user's email address is derived from the primary category of identity. In a similar manner, in a mobile journey planner, distances to various bus stations are derivatives of the primary category of location.

Sometimes, multiple primary categories are needed to index a context factor. For instance, forecasted weather conditions require location and time (Dey & Abowd, 1999). It must be noted, however, that there is a trade-off between abstraction and the context accuracy (Lieberman & Selker, 2000), which makes final, unambiguous context categorization hard to achieve. For example, for producing playlists for "relaxing", designers may need to involve measurements or user-provided values of identity and activity – maybe even location and time – or a combination of all four. Even the seemingly uncomplicated context factor location has been applied for a spectrum of recommendation strategies, ranging from transitory encounters with collocated people and their music preferences to attaching music to places (for a thorough review on contextual music recommendation research systems, see Article V).

## 2.2 Context as a stage for meaning-making

Design theorist Klaus Krippendorff (2006; 2007) has examined context in his theory of product semantics. While not explicitly defining context, Krippendorff views it as a stage for meaning-making through the use of artifacts. The cornerstone of Krippendorff's thinking is that *meanings are derived from the use of artifacts in various situations*, that is, their *contextualizations*. People do not see objects, but what they mean to them under different conditions. There are unavoidably three different qualities of interactions with artifacts: *observing, interfacing* (interacting) and *anticipating* use. People first observe the meaningfulness of artifacts, then interact with artifacts based on their meanings (e.g. affordances) and anticipate the future contexts of use from narratives about particular artifacts. Meanings of artifacts are constructed by users in relation to artifacts in different contexts, and the meanings of



artifacts for a user may change completely in different contexts. For example, a bottle can function in different contexts as a container for liquid, a candle-holder, or a decorative object.



**Figure 1** Examples of context factors in a real-life situation: location (“food truck”), time (“evening”, “winter”), activity (“eating”) and identity (“friends”, “vendors”) following Dey and Abowd’s (1999) definition.

### 2.3 Context as activity: embodied interaction

Paul Dourish is one of the leading HCI theorists, having thoroughly addressed the concept of context as well. For Dourish (2004), the view of context as a type of information (Dey & Abowd, 1999) stems from the tradition of Positivism. Positivism is a school of philosophy of science that sees natural sciences and its methods aiming for objectivity as an ideal for the fields of research on people as well (Dourish, 2004). Instead, Dourish’s preferred view of context builds on the Phenomenological tradition, which sees phenomena occurring immediately and subjectively to an observing person, resulting in subjective experiences. According to Phenomenological view, context is not a frame wherein activity happens, but it is seen rising from activity. Dourish compares the common (Positivist) HCI view of context with the Phenomenological view along four points, presented in Table 1.

Positivist view	Phenomenological view
Context is a form of information.	Context is a relational property between objects and activities.
Context is delineable, definable in advance.	The scope of contextual features is defined dynamically, as activity unfolds.
Context is stable.	<i>Context is an occasioned property, relevant to particular settings, particular instances of action, and particular parties to that action.</i>
<i>Context and activity are separable.</i> Activity happens within a context.	Context arises from the activity. Context isn't "there," but is actively produced, maintained and enacted in the course of the activity at hand.

**Table 1** The Positivist and Phenomenological views of context according to Dourish (2004).

For Dourish, Positivist view (such as discussed in Dey & Abowd, 1999) is about seeing context as *a form of information* and a problem of *representation*. Context can be known before the actual use situation and encoded into systems just as any other information type. According to the Phenomenological view, however, context is not a representational problem, but a *relational property* between objects and activities, thus making it a problem concerning *interaction*. Typically, HCI sees context as *delineable*; possible to define the context that the application supports and where it functions before the actual use. According to the Phenomenological view, *the scope of contextual features is defined dynamically*, in the course of actions between users and technologies. (Dourish, 2004.)

Typically, HCI (e.g. Dey & Abowd, 1999) sees context as *stable*, whereas according to the Phenomenological view context varies across situations, activities and actions. Therefore, it is *an occasioned property*, varying in different

settings, different actions and agents involved in the action. Finally, while Positivist view sees *context and activity separable*, activity occurring “within” a context, Phenomenological view argues that *context arises from the activity*. (Dourish, 2004, 14.)

In Dourish’s (2004) Phenomenological view of context, activity and context are “mutually constituent”; their relation is bidirectional. He calls this approach “embodied interaction”. Its essential implication for design is the idea “of allowing users to negotiate and evolve systems of practice and meaning in the course of their interaction with information systems” (Ibid., 14). Embodiment refers not only to physical reality, but it is essentially about availability for engagement. By stating that “the embodied-interaction perspective is concerned with the way in which the meaningfulness of artifacts arises out of their use within systems of practice” (ibid., 14), Dourish’s view of context nearly converges with Krippendorff’s (2006; 2007) semantic view of context: meanings are constructed from the use of artifacts in various situations. I will next discuss the significance of the aforementioned views to the design of interactive systems.

## 2.4 Implications for design

Dey and Abowd’s (1999) definition is explicitly directed to practical design work. However, Dourish’s and Krippendorff’s views on context as a stage for active meaning-making can also be applied for providing inspiration as well as analytical tools. Human conduct is inherently improvisational and designers may choose to support and enable creative use of computing systems. Designing contextual services and designing for various contexts means not only involving contextual attributions to design (as in Dey and Abowd’s operational definition), but also designing for unpredictability, for the real-life use situations that often are unpredictable. Leaving a certain amount of openness and adaptability to the systems for unexpected activity or personal meaning-making can provide better user experience (UX). *Designing for unpredictability allows also designing for serendipity.*

For example, in our prototype of a location-sensitive music discovery app (Article IV), locations and music content were left open for the users to choose (as opposed to curated services). Also, an open text field was provided for whatever information or comment users wanted to share with other users. The results of the field study showed that participants appreciated the

serendipitous discoveries and open meaning-making enabled by the application (Article IV).

Although modern mobile devices are capable of measuring many contextual information types, there are myriads of those that remain to be out of the scope of technical measurements. For example, the company of other people (i.e. social context) is currently rarely included among the context factors, with Facebook's facial recognition providing a rare mainstream example. In most of the existing cases, social context must be provided by users through giving the application information about whom she is with, or the number of people in the vicinity, or whether those people are strangers or friends, to name a few social dimensions. Therefore, Dourish's critique towards the view of context as only measurable types of information is relevant. Designers are able to have some control over some of the factors, but for the variables or factors that escape control, it is recommendable to leave choices open for users.

Dourish's *practice-centered* and Krippendorff's *meanings-centered* views may prove useful in various phases of a design process and for different purposes. For example, the actions and interactions that are supported in a mobile app explicitly, and also those that are possible, but not primary actions for the app to work, may be listed and analyzed in various phases of a design process, then deciding which ones are the most crucial to support.

## 2.5 Summary

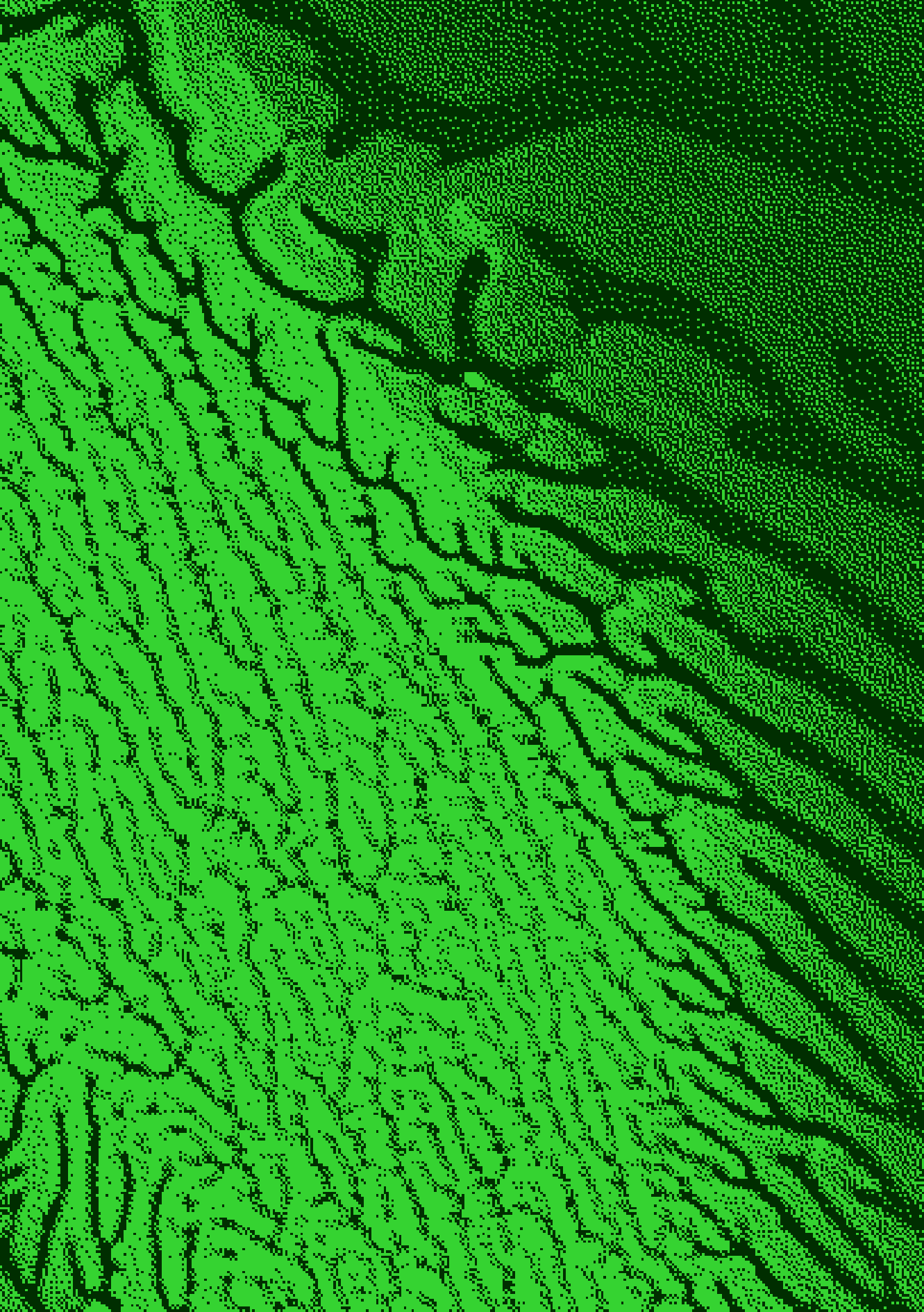
In the following, I summarize the presented views on context and evaluate their contribution and usefulness for design and research practices. To begin with, Dourish does not want to define context in an exact manner, or present a concept for practical work as Dey and Abowd do, but takes a strong normative stance, arguing that real-life unexpectedness must be considered in design by openness of design. This is the case specifically in ubiquitous applications and context-aware computing with constantly changing situations of use. According to Dourish, context rises from activity and the former does not exist without the latter. He calls this approach "embodied interaction". It is an alternative term for context-aware computing highlighting change and action. All three views combined, action between users and technology over time (Dourish) creates constantly changing meanings (Krippendorff) that make different kinds of information more relevant than others (Dey & Abowd) in various phases of the application use. While Dey and Abowd's

contribution lies in the explicit definition, and Krippendorff's contribution in highlighting the meanings users construct in different situations of use, I see that one of the most important practical benefits of Dourish's view is the suggestion to leave something open in design, for example for repurposive appropriation and creative novel uses of technology (Salovaara, 2012). Dourish mentions the cases of telephony and SMS of users creating new, unexpected uses for technologies (Fischer, 1992; Ling & Yttri, 2002).

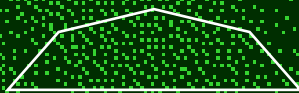
Unlike early HCI views (as presented in Dey and Abowd, 1999; see Section 2.1), the three views of context share a common characteristic of being dynamic. They highlight the element of change (of information, activity or meanings) through interaction. In Dey and Abowd's view, activity is one of the four primary types of changing contextual information, for Dourish, context is an occasioned, generated property produced through activity, and for Krippendorff, meanings of artifacts change through their use situations (context). Difference between Dey and Abowd and the other two is that while they strive for descriptive, value-free definition, the other theorists use context as a normative, prescriptive concept: the aim of designing ubiquitous computing applications should be allowing users openly decide meanings and come up with new uses with technologies. As meanings are the cornerstone of Krippendorff's (2006) thinking, he does not examine the concept of context as such but only in relation to meanings. Dourish sees that the question of context is more a change of perspective from the descriptive features of a use situation to activity and practices, what people do in those settings and by that, the constantly evolving meaning-making that happens in the users' interaction with technologies.

In this thesis, in place of "context" as a frame wherein something happens, I will use "use situation" or "situation of use". "Contextual information" will be used as in Dey and Abowd's (1999) definition, referring to the types of information relevant to the use situation. While other primary context types are quite self-explanatory, I will use *identity* referring not only to a single user but also his or her *social context*, the people (e.g. their social media updates) that are relevant to that particular use situation.

While I have mainly employed Dey and Abowd's definition in mapping design options and for analyzing the existing services, Krippendorff's and Dourish's views are certainly useful in explaining the use of a system or activity with it as well as the meanings people construct while using it. In the next chapter, I present another important area to this work, *music recommendation systems research* and its central concepts.



# 3 RESEARCH FRAMEWORK: MUSIC RECOMMENDATION AND DISCOVERY

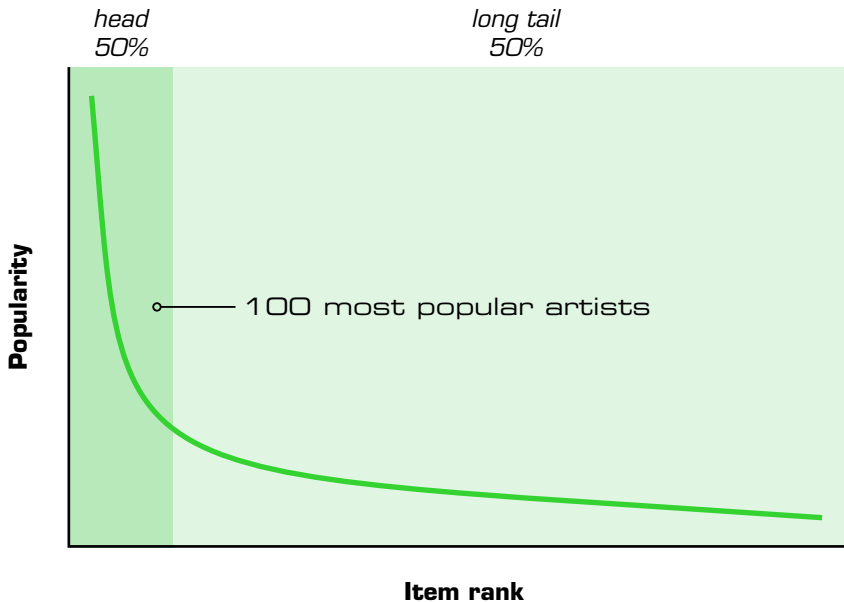


In a technical sense, music recommendation refers to systems that give recommendations automatically by using various computational means, such as algorithms and signal analysis (Herlocker, Konstan, Terveen, & Riedl, 2004; Celma, 2010; Ricci et al., 2015). Music recommendation systems research is typically a very technical field, often focusing on developing better algorithms (see literature in Ricci et al., 2015). In the field of *information retrieval*, music-related research is typically conducted in music information retrieval (MIR), which has an established annual ISMIR conference since 2000. Within *recommendation systems research*, there is a conference series dedicated to the different aspects of recommendation systems and services, ACM RecSys (annually from 2007). Both conference series cover HCI and UI aspects of music recommendation and discovery as well. Following the focus of this work, in this chapter, I summarize the most important concepts of music recommendation research that can be supported also by interaction design.

Music is one of the most ubiquitous commodities today, with tens of millions of tracks available online. Services offering music (e.g. Spotify, YouTube, Vimeo, Pandora, Deezer) are available free for all consumers with an Internet connection. Indeed, the availability of the online music libraries is more a question about access (e.g. some countries blocking access to certain online content) than about money. However, finding novel and relevant music from the vast collections can be difficult due to the overwhelming variety. Users may feel doubtful, even paralyzed when facing the vast libraries of non-personalized music (Scheibehenne, Greifeneder, & Todd, 2010; Schwartz, 2004). To overcome this, choices can be narrowed down by including automated recommendation and personalized filters to help users' decision-making (Celma, 2010). Furthermore, the problem of finding novel, non-mainstream music can be approached by applying recommendation strategies that suggest music from the tail end of the long tail curve (explained in Figure 2). Recommending music from the tail end is an important strategy in promoting serendipity and ultimately cultural diversity,



as discussed in 1.1. Music recommendation is only one area where long tail curve can be applied, as discussed by Anderson (2006).



**Figure 2** Popularity curve (i.e. long tail), showing that in music recommenders, typically around 50% of the recommendations are based on a pool of around 100 most popular artists, leaving the rest (i.e. hundreds of thousands) artists in marginal (adapted from Celma, 2010)

### 3.1 Idiosyncrasies of music recommendation

The majority of music recommendation systems have applied techniques such as collaborative filtering from different domains (e.g. books, films, online dating and travel) to music (Celma, 2010). However, music differs from other entertainment domains in many ways. Drawing from the

research on music recommendation (Celma, 2010; Schedl, Knees, McFee, Bogdanov, & Kaminskas, 2015), the most significant idiosyncrasies are:

- Implicit preference elicitation
- Easy and inexpensive to access
- No need for owning the content
- Repeated use
- Short evaluation process for the recommendations offered
- Highly contextual
- Does not require full attention

In music recommenders, users' preferences are typically elicited implicitly, through their listening habits, instead of asking them to explicitly rate items. Furthermore, online music recommenders are easy to access and many of them are free, or give access to tens of millions of music tracks for a small monthly fee, making the cost per item very low (Article I; Celma, 2010). Because of the online music services, there is also no need to own a large personal collection of physical music discs or digital files. In addition, users listen to the albums, tracks or playlists several times, often repeatedly. Moreover, compared with books or films, it takes only a little time to evaluate the quality of recommendation results (Celma, 2010). Also, music use is by nature highly contextual, situation-dependent; different music is chosen for different situations, and ubiquitous music technologies only accelerate this quality (Bull, 2008; DeNora, 2000). For example, music choices depend greatly on social setting and people often have different listening habits when listening to music alone versus when in other people's company. Finally, another quality that highlights the ubiquitous nature of music consumption is that it does not require our full attention, enabling listening during other activities (Levitin, 2007), for instance, during work-related computer use or sports activities.

Designers need to consider the above qualities to a varying extent, case by case. For example, a mobile app for exercising has to address various context information types differently compared with a social jukebox located in a music bar.

### 3.2 Evolution of recommendation systems

Word of mouth or human-to-human recommendation is probably as old as human social behavior. Together with radio and social media, it still remains the main channel for discovering new music (Nielsen Music 360 report, 2012). Automated, computer-based recommendation systems date back to the 1990s when systems for finding relevant texts from the large text databases of bulletin boards were developed. Today, automated recommendations are applied to various areas such as legal documents, travel, entertainment (films, books, music) and online dating services (Adomavicius & Tuzhilin, 2015). In music domain, EchoNest ([www.echonest.com](http://www.echonest.com)), acquired by Spotify in 2014, is the leading company delivering the machine learning and music data for various commercial services, including Spotify and SiriusXM, both having tens of millions of users (as of 2016).

### 3.3 Recommendation techniques and methods

In its basic form, automated music recommendation follows a two-dimensional model: a system recommends the user either items from its database (i.e. music tracks or artists) or other users of the system. In this work, music discovery refers to the user's experience of finding new music and music recommendation to the technical means or the (human) act of recommending. I will mostly use the terms together: *music recommendation and discovery*.

There are five basic approaches (and a sixth, recent addition, contextual recommendation) to music recommendation (summarized from Celma, 2010; Ricci et al., 2015; Schedl et al., 2015):

1. Human to human recommendations function by experts or other users (DJs, journalists, music enthusiasts, professional critics, bloggers) recommending music face-to-face or using various communication channels such as social media, weblogs, and radio.
2. Demographic filtering is carried out typically by recommending users music that is listened to by people of a similar sex or age segment. It is currently rarely applied for music recommendation (Celma, 2010).

3. Collaborative filtering (CF) is a popular way of producing automated recommendations. It can be divided into three subsets: user-based, item-based and model-based approaches. In CF, the research focus has traditionally been on developing better and better algorithms.
4. Content-based recommendation is commonly carried out by recognizing item similarity. This is conducted usually on a track level. The audio signal is analyzed and then pieces of music are recommended based on similarities in rhythm, harmonics or signal intensity.
5. Hybrid methods typically combine collaborative filtering and content-based recommendations. Commercial services using algorithmic approaches often also incorporate some kind of expert or user-made recommendations or information about the content recommended, thus making them hybrid systems.
6. Contextual recommendation is a relatively new approach to music recommendation, utilizing contextual information types such as time, location, weather or social setting on recommendations (Adomavicius & Tuzhilin, 2015; Dey & Abowd, 1999).

Algorithm-based recommendation systems are subject to the problems of *cold start*, *popularity bias* and *filter bubble*. Many recommendation systems require the user to explicitly annotate or rate items (i.e. to “train” the system). Without annotations or ratings, these recommenders are not able to tackle new users or new items; without previous use, they cannot calculate which song the user would like. This is referred to as cold-start problem (Schein, Popescul, Ungar, & Pennock, 2002). Popularity bias means that recommendations tend to concentrate on the items that are popular instead of supporting users to find unfamiliar content (Article II; Fleder & Hosanagar, 2007). In online systems, people are often only exposed to the content that is in line with their personal social connections and use history (Article II; Pariser, 2011). In recommendation systems, this is called collaborative filtering feedback or filter bubble.

One of our prototypes, Sounds of Helsinki (Article II) suggests a partial solution to the above-mentioned problems by offering ad-hoc

recommendations. In this prototype, users do not have to train the recommender nor provide a seed track. Instead, recommendations are pushed to the user based on her location and time. Neither of two prototypes (Sounds of Helsinki, OUTmedia) presented in this dissertation required users to train the recommender in any way, and only Sounds of Helsinki applies recommendation algorithms.

### 3.4 Common use cases in music recommendation

Common use cases describe various goals that people may have when using a music recommender. While users may also have goals such as manipulating the recommender algorithms or other users (Herlocker et al., 2004), I focus on the goals related to finding relevant (i.e. good), novel or positively surprising music content. Beyond the obvious "find me a good song" use case, Celma (2010) lists the most common use cases as artist, playlist and neighbor recommendation.

1. *Artist recommendation* matches user profiles to artists. Many online services (e.g. iTunes store, Spotify, Last.fm) also provide additional information about gigs, lyrics, merchandise and other music metadata that can be used to produce more accurate artist-related recommendations. Research shows that additional information makes the user experience richer by giving the user cultural hints about the relevance of the music content (Celma, 2010; Celma & Lamere, 2011). Contextual information, mainly location and time, are sometimes (e.g. in Spotify) applied for informing the user about her favorite artists' concerts in nearby cities.
2. *Automated playlist generation*. Playlists are commonly generated by providing a random list of songs (i.e. shuffle mode) or based on user given seed (artist or song). Shuffle playlisting has been shown to promote serendipitous or pseudo-serendipitous re-discoveries, by presenting familiar songs on a different order and thus creating new meanings within user (Leong & Wright, 2013). Playlist listening is also a good way to provide the system immediate feedback while the user can focus on listening. By skipping, liking or unliking the user can have an effect on her profile in real

time, resulting in more relevant recommendations, in this case, *personalized playlisting*. (Celma, 2010; Article I). For example, online personalized radio Pandora as well as streaming service Spotify apply this approach to produce automated playlists based on seed artists (“artist radio stations”). While playlists typically focus on providing music for tuning into an emotional state or as a background for an activity such as exercising or reading (Celma & Lamere, 2011), a mix is a playlist with a premeditated order of tracks (Cunningham & Masoodian, 2007).

3. *Neighbor recommendation* aims at finding and connecting people having a similar taste in music. It is based on matching user profiles with other users’ profiles (*user-user* matching) (Celma, 2010). The system connects the user to a cluster of other users, “a neighborhood”, which is applied for recommending other people from the surrounding users’ profiles or interacting with the neighbor community by using social media features or other communication tools. The main added value of creating neighborhoods lies in the community building. People who have more or less similar taste for music, often share other common interests as well. Most online music services (e.g. Last.fm, Spotify) provide users tools for communicating with like-minded people.

## 3.5 Suggestions for novel recommendation cases

### 3.5.1 Pseudo-serendipity as forgotten good music

Every now and then a music listener encounters a piece of music that she has liked previously, but forgotten it, and now, years later, the musical reunion results in a pleasant experience. This music is relevant, positively surprising, although not new to the user. Following Celma (2010), these encounters can be called “pseudo-serendipitous” and might be supported in recommendation systems, not least because of the nostalgic value, often triggering a whole chain of memories from the time the song was part of the user’s life. For example, recommending a Robert Palmer song the user used to listen when she was 12 but had completely forgotten its existence

by the age of 40 would pose an interesting use case for the designers of music recommenders. This raises a question of should there be a recommendation category or a design goal for "nostalgic" or "forgotten pearls" recommendations?

### 3.5.2 Ultra long tail discovery

There are several online services that offer free access for uploading the user's own music. For example, Soundcloud has millions of users and hundreds of thousands of music tracks from unsigned artists. Typically, these kinds of services do not have any kind of recommendation facility. An interesting use case would be to include a recommendation facility embracing long tail ideology. "Ultra long tail discovery" would recommend unsigned and other utterly marginal artists from Soundcloud and similar services. In its simplest form, this could be implemented by giving a name of an artist that has released music through "official" services such as Pandora or Spotify as a recommendation seed, then using content-based or hybrid techniques to offer the users similar unpublished music.

## 3.6 Characteristics of successful music recommendations

In one of the few interaction-focused studies on music recommenders, Jones and Pu (2007) conducted a user study with 64 participants. They aimed to understand users' initial adoption and subjective user perceptions of two popular online music recommenders, Pandora ([www.pandora.com](http://www.pandora.com)) and Last.fm ([www.last.fm](http://www.last.fm)). Their results show that the users appreciated simple interface design with little initial effort required to get a recommendation. Key design factors included user perceived qualities of subjective accuracy, novelty and enjoyability of the recommended music tracks. According to Jones and Pu (2007), these factors remarkably enhanced the studied services' user experience.

More elaborated list of the dimensions crucial for designing good music recommendations is summarized from the works by Celma (2010) and Celma and Lamere (2011), consisting of:

- Relevance
- Novelty
- Serendipity
- Reach and diversity
- Transparency
- User's context (i.e. situation of use).

### 3.6.1 Dimensions of content quality

*Relevance, novelty and serendipity.* In recommendations offered to users, high-relevance items are those that rate high on user perceived goodness (Adomavicius & Tuzhilin, 2015). The debate over the definition of relevance and the right way to calculate it has been going on for years in the field of information retrieval (Ricci et al., 2015; Harter, 1996).

*Novelty (or discovery)* is one of the most important dimensions in recommender system research, describing the extent to which users receive recommendations that are unfamiliar to them. Novelty is usually assessed by subjective evaluation through user surveys. (Pu, 2010).

*Serendipity* is best described as a conjunction of novelty and relevance (Castells, Hurley, & Vargas, 2015) (see Figure 3). For instance, if the user has liked the entire Daft Punk back catalog, the recommender may offer her a brand new Daft Punk album that she has not heard previously. The album is novel to the user, but not serendipitous since the artist is a familiar one. If the recommender offers artist totally new to the user, that might be a serendipitous recommendation (if the user finds the artist's music relevant as well). Recommendations that are serendipitous are by definition also novel (Herlocker et al., 2004; Castells et al., 2015; Schedl, Hauger, & Schnitzer, 2012).

Serendipitous recommendations are novel, relevant, and often have an element of surprise in them as well. Pu and Chen (2010) have conducted a number of extensive user studies on recommenders, remarking that in practical user evaluation, a strict distinction between novelty and serendipity may cause confusion for users since they may not be familiar with the academic definitions of the concepts. Therefore, when measuring novelty and serendipity in user studies, they suggest using two similarly operationalized questions:



- “The items recommended to me are new and interesting”
- “The recommender system helps me in discovering new products”

*Reach and diversity.* Reach is achieved through recommending a diverse set of content, not only from the head but from the tail end of the long tail as well (see Figure 2) (Anderson, 2006; Celma, 2010). Castells et al. (2015) contrast novelty and diversity by stating that novelty refers to the difference between present and past experiences, while diversity concerns with how different the recommended items are compared with each other. Most recommenders tend to suggest mainly popular music. However, for the sake of cultural diversity (see UNESCO, 2001), it is important that recommenders offer all kinds of music, including new releases and marginal music (Ferwerda, Graus, Vall, Tkaléc, & Schedl, 2017).

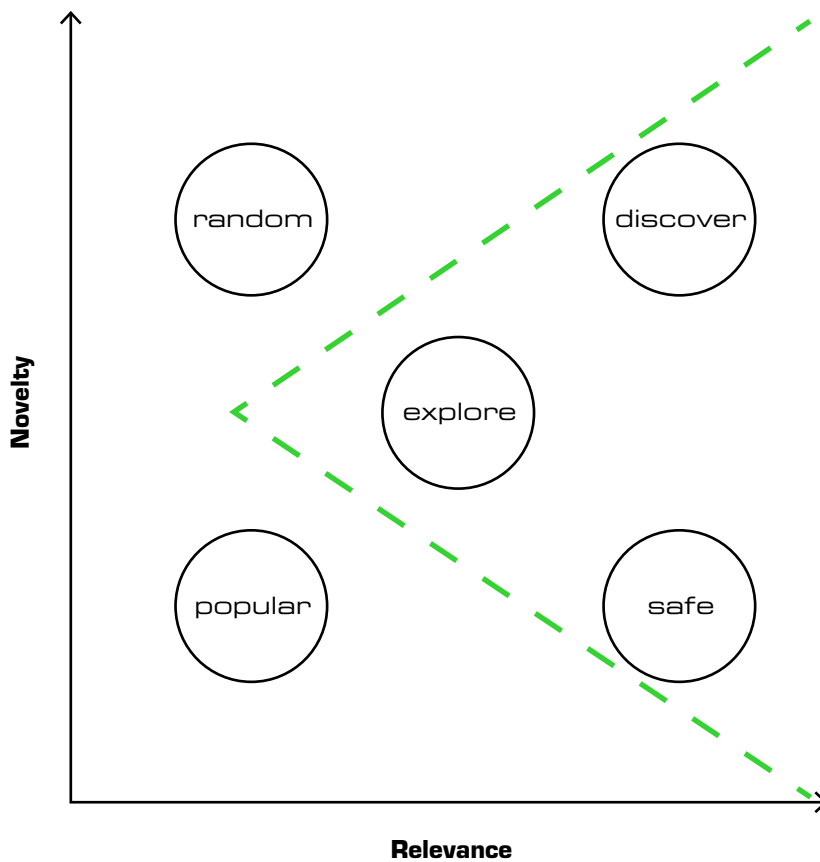
Reach and diversity pose a challenge to music recommenders because of the dynamic nature of the music ecosystem. The musical style of an artist may change quite substantially over the years, as may a listener’s taste. With millions of artists, music tracks and listeners, it is hard to build a recommender that reaches all content (Celma & Lamere, 2011).

There are several benefits to diversity and reach. From an ethical viewpoint, cultural diversity can be comprehended beneficial for culture as such (UNESCO, 2001). For businesses, having a diverse supply allows “selling less of more” (Anderson, 2006), that is, selling large numbers of items that sell in small quantities from the tail end of the long tail curve, so that the sales may outnumber the sales of a few popular items from the head part of the curve (Figure 2). Finally, for those consumers who value finding new, relevant or serendipitous music, diverse music libraries or databases are an invaluable resource.

Instead of relevance, recommendation accuracy has traditionally been the most common dimension in evaluating the quality of recommendations. That is, systems have been measured according to their ability to making accurate predictions on the user’s music preferences (Celma, 2010). However, according to the state-of-the-art in recommendation systems research (see Ricci et al., 2015) accurate recommendations do not guarantee a satisfying user experience. Recommenders are useful if they are able to help users complete their tasks.

Developing and technically evaluating algorithms is a thriving research area of its own. However, my purpose is to study recommenders in the tradition of user-centered design (Norman 2002), which typically builds on user

data, such as observing and interviewing people on their use of interactive prototypes and their interfaces. Therefore, I will not present a review of the state-of-the-art of music recommendation algorithms



**Figure 3** Relation and trade-off between novelty and relevance (adapted from Celma, 2010). High values of novelty and relevance typically allow serendipitous discoveries.

### 3.6.2 User interface: dimensions of interaction adequacy: transparency

Of the dimensions of interaction adequacy, I focus here on transparency (as highlighted by Celma & Lamere, 2011), which is one of the functions that can be supported through recommendation explanations. Transparency can effectively enhance the UX of music recommenders (Article V) by telling the users why recommendations were generated or revealing the system logic (Tintarev & Masthoff, 2015). In other words, transparency answers the vital question of “why this item was recommended to you?” In contextual music recommendation, transparency can be applied for example for revealing the context factors that were applied for producing the recommendation.

Many recommender systems are still black boxes, with no features for transparency. Several studies have found that explanations have many advantages, from enhancing user acceptance, promoting trust towards the system and helping users in making good decisions (Sinha & Swearingen 2002; Tintarev & Masthoff, 2007). Tintarev and Masthoff (2015) have presented a comprehensive categorization for the functions of explanations, listing for instance transparency, efficiency, persuasiveness, and effectiveness, as well as providing guidelines for the optimization of explanations.

Users also face the task of evaluating a system’s recommendations. For example, the mere title of a music track may not be sufficient for all users to convince to try it. Therefore, the availability and quality of the information a recommender provides (e.g. reviews, videos, sound samples) to support the decision-making process has been showed to be a significant factor in predicting how useful users rate the system (Kaminskas & Ricci, 2012).

### 3.6.3 User’s context

As described in Chapter 2, in this thesis, context is referred to as a situation of use, which can be described through four primary context factors of location, time, identity and activity (Dey & Abowd, 1999). For a third-millennium music consumer, music content is highly portable and music discovery and recommendation services should be available ubiquitously. Therefore, adding user’s context into the recommendation process is increasingly important, but currently poorly supported. Traditionally, music has been recommended using a two-dimensional model: users are recommended items (music tracks) or other users. In contextual recommendation,

potentially many more dimensions are added. Research prototypes for contextual recommendation and discovery services are addresses at length in Article V.

### 3.7 Model of levels of contextual music recommendation user experience

1. Content quality	2. User interface	3. Context factors	4. Concept level
Relevance Novelty Serendipity Reach Diversity	<b>Interaction adequacy:</b> User effort Presentation Transparency & explanations Multifunctionality Serendipity	Location Time Identity Activity	

**Table 2** The model of contextual music recommendation and discovery UX.

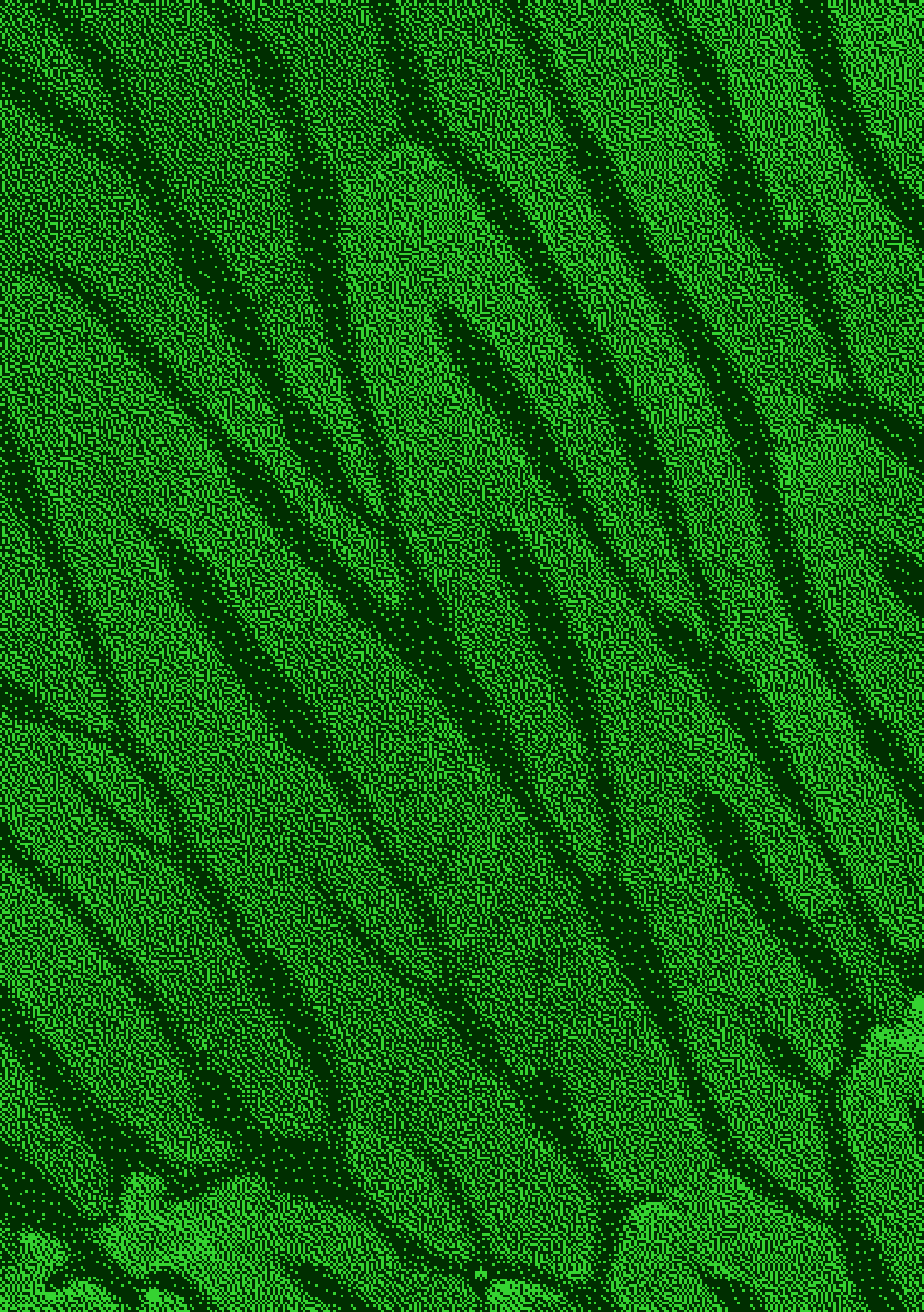
The model, presented in Table 2, has been created by combining dimensions from the previous sections of this chapter. The levels are different analytical viewpoints to contextual music recommendation UX. The relations between the different levels and their possible hierarchy would be a complex design-philosophical question and beyond the scope of this work. Therefore, the levels are not presented in a hierarchical manner.

1. *Content level:* relevance, novelty and serendipity are subjectively perceived dimensions of music content, whereas reach and diversity can be measured objectively. The content level is the most intimate and subjectively evaluated level of contextual music UX.

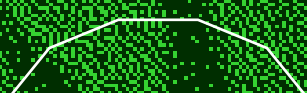
2. *UI level*: interaction adequacy covers the dimensions of user effort, presentation, refinement and transparency. These dimensions are thoroughly discussed in Article V that reviews the research systems of contextual music recommendation and discovery. On the interaction level, the user interacts with recorded pieces of music for example by choosing a music track from a list of recommendations for listening.
3. *Context factors* refer to Dey and Abowd's (1999) definition of context discussed in Chapter 2. On context level, factors describing the user's situation are utilized to enrich music recommendation.
4. *Concept level* covers design decisions beyond the interactional features, such as letting the users annotate their recommendations and the effect those decisions have to the UX. Concept level themes arise from the user data, therefore the column is left empty at this point.

### 3.8 Summary

In this chapter, I reviewed the central dimensions of music recommendation that can be supported by user interaction, context factors and concept design. The most important dimensions from this standpoint for good music recommendations are relevance, novelty, serendipity, trust and transparency, reach and diversity as well as the user's context. I also presented a model of levels of contextual music recommendation UX, expanding and complementing the list by Celma (2010) and Celma & Lamere (2011) presented in 3.6, summarizing most of the dimensions presented in this chapter. The model will be used for presenting my contribution in Chapter 5.



# 4 DESIGN AND RESEARCH PROCESS



This section describes the design and research process of the two prototypes that constitute the empirical contribution of this work, Sounds of Helsinki and OUTMedia (Articles II, IV). The general research objective was to design new kinds of interactions for browsing and discovering media content by augmenting urban reality through applications that utilize contextual information, specifically location, together with time and identity. By describing the process, the aim is to give the reader an account of the methods, user involvement, design artifacts and the produced data in a chronological, narrative form.

The approach throughout the process was similar to the design and research practices prevalent in contemporary design research and HCI. These typically involve users for concept ideation and prototype evaluation in field studies. The design and research process as a whole can be described as *user-centered design* (UCD) (for the definition of UCD, see International Organization for Standardization, 2010; Lee, 2012). The intensity of user involvement varies through the process: it was high during the user workshops (referred to as *co-design*) and nearly non-existent during development phases (Figure 4). *Co-design* refers to the collective creativity applied through the design process, where designers collaborate with people not trained in design work (Albinsson, Lind, & Forsgren, 2007; Lee, 2012; Sanders & Stappers, 2008).

Research and design tasks were shared among a team of three researchers. The background of the team was multidisciplinary: the team members are experts in design, computer science, cognitive psychology, social sciences and software development. The process had two iterative cycles of the following phases: concept creation, user workshop, prototype development, user study, data analysis, and reporting (Figure 4).

**Figure 4** The design and research process (of the work reported in Articles II, III and IV): methods, user involvement, design artifacts and types of data produced.



	Concept design	User workshop	Prototype design	Field study	Analysis & reporting
Methods	Expert and co-design methods	Co-design methods	Internal design & development	<p><b>1. cycle:</b> independent prototype use</p> <p><b>2. cycle:</b> accompanied use</p> <p><b>1 &amp; 2:</b> interviews, survey, focus groups</p>	Grounded theory, survey data analysis, quantitative analysis
Design artifacts	Focus groups, interviews, scenario narratives, visualizations	Focus groups, interviews, scenario narratives, visualizations, audio & video recordings	Requirement lists, visualizations, online content management system	Focus groups, interviews, scenario narratives, visualizations, audio & video recordings, online content management system	Qualitative and quantitative analysis tables, graphs, written documents, audio & video recordings
Data	<b>Qualitative:</b> requirements, concepts	<b>Qualitative:</b> opinions, design drivers	<b>Qualitative:</b> iterative prototypes	<p><b>Qualitative:</b> opinions</p> <p><b>Quantitative:</b> surveys, interaction logs</p>	<p><b>Qualitative:</b> themes</p> <p><b>Quantitative:</b> quality of recommendations, UI</p>
Intensity of user involvement	Mixed, internal and expert co-design	High, co-design	None, internal design	High, co-design	None, internal analysis



## 4.1 First prototype: Sounds of Helsinki

Our exploration with contextual music services started during Musiquitous research project (2009–2012), which focused on *interacting with recorded music* and involved a multidisciplinary team of designers and researchers from four universities. The research agenda of the project was threefold: to study the history, presence and future potential of the interactions with recorded music, of which the work described here belongs to the future category. The original idea was to design a service that would visualize music listened to in different districts of the city as a map mash-up. The prototype could then be used for studying the ways in which musical “memes” or new releases spread through the city or for illustrating geospatial differences in music tastes.

Through internal discussions, brainstorming, socio-technological analysis, literature review and expert workshops and seminars at Aalto University’s Helsinki Institute for Information Technology HIIT and Media Lab Helsinki, and at a Nordic research network’s “The Culture of Ubiquitous Information” seminar at the University of Copenhagen, we created three foundational concepts that were later evaluated in the user workshop. The foundational concepts shared some common characteristics: they applied location as the main context factor, included map visualization, could be conceived both as research tools and as potential commercial services and could be implemented with the available resources.

As the concepts and their motivations are described in Article III, they are presented only briefly here. *Sounds of Helsinki* was based on an idea that districts of a city have their own identities and socio-cultural structures, and these geo-cultural idiosyncrasies reflecting the music listened in different areas could be visualized on a map user interface. *Musical Hotspots* was a general level concept for various ideas about linking music with locations meaningful to the users in order to create hotspots and trails of music in the city. Location-sound combinations would evolve, change and fade over time to be found by other people, resulting in a city scattered with sound. In *Musical Treasure Hunt*, users would seek musical treasures marked by GPS coordinates in a similar manner as in geocaching. It would have been also possible to gather musical clues in different points of a musical treasure path, and add time-based competitions.

#### 4.1.1 Co-design workshop

A workshop was organized for two goals: to collaboratively ideate potential situations for contextual music recommendation and to evaluate three initial concepts described in Article III. User data was also applied for formulating the main design principles that guided the design decisions.

Eight early adopters of music services aged 18–40 participated in the workshop. Early adopters are people who adopt new technologies and innovations in their everyday life earlier than the majority of a certain population (Rogers, 2003). They were recruited through social media snowballing. I ensured that the participants belonged to the group of early adopters by interviewing them before accepting them to participate. I asked for example which music services they use and if they search for new music on a weekly or daily basis. This phase of the process was characterized by intense user involvement, resulting in activities similar to participatory design and service design approaches, strains of HCD renowned for their use of visual materials and physical tools and activities through close collaboration between the users and researchers (see Dindler, 2010; Dourish, 2001; Ehn, 1988; Greenbaum & Kyng, 1991; Kimbell, 2009).

In order to involve participants as resources for the design and research process efficiently, we planned the workshop agenda carefully. We gave participants clearly focused tasks with the help of a set of prepared design artifacts (visualizations and scenarios). The main output from the workshop was acquiring potential situations and places for contextual music recommendation. Design principles were formulated partly from the user data of the workshop.

The workshop was structured around three tasks. The first two tasks focused on the ideation of potential situations, needs and desires related to context-aware music recommendation. In the third task, we presented three internally created service concepts and asked participants to evaluate them in terms of their attractiveness and feasibility. I will here focus on the first two tasks since the third task did not include social interaction. It gathered feedback from the initial concepts by presenting the concepts as visual scenario narratives (Carroll, 2000) and gathering responses in text.



**Figure 5** Evaluating user-created scenarios at the first early adopter workshop.

The participants were given a list of premises to frame the design space, a construction of (a partly fictional) reality wherein the ideation of potential situations happened (as discussed by Binder et al., 2011; Dindler, 2010; Heape, 2007; Schön, 1992).

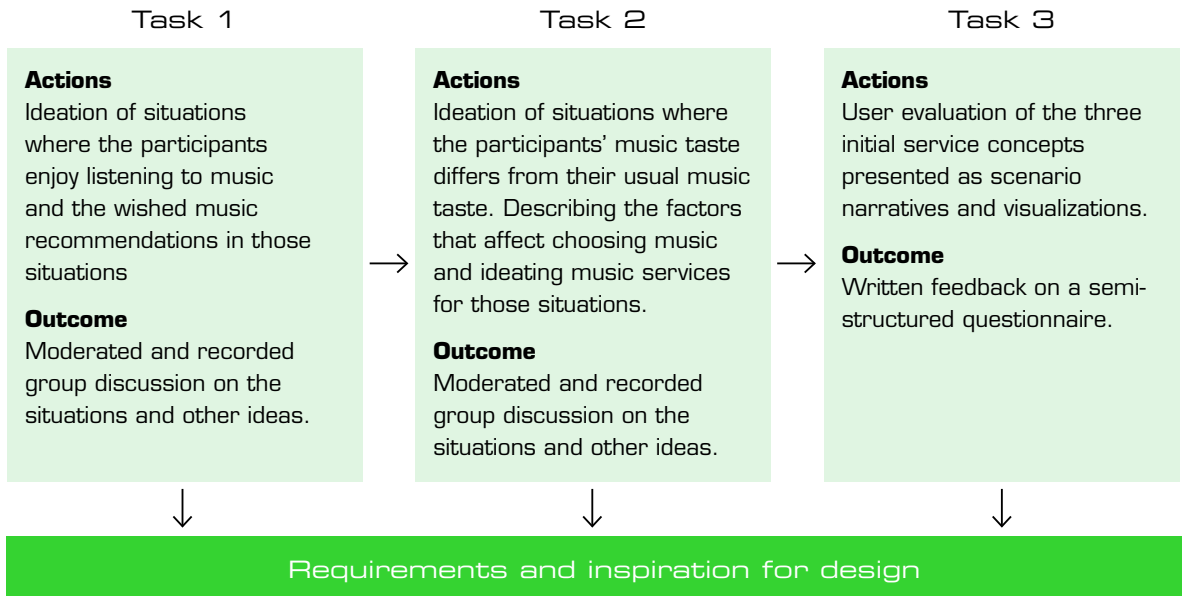
The premises were:

- every piece of music ever recorded is available wherever and
- whenever,
- shareable to anyone or a desired group of people,
- with a possibility to link music to places according to
- various user-selected context factors such as time, social context, weather and activity.

We also postulated that copyright and privacy issues are taken care of in a feasible way so that any music is available at a nominal cost and that privacy issues of meta-information and user-created content sharing are taken care of.

In the first task, participants were asked to imagine and describe situations where they enjoy listening to music. The goal of the task was to explore different situations where different kinds of music related needs and desires emerge and discuss the factors that make people choose certain music in a situation. They were also asked to describe what kind of music recommendations they would like to be offered in those situations and provide reasons why they would like to have that kind of service in that particular situation.

Photos of people in various situations were shown as inspiration, including traveling, commuting, cycling, jogging, lazing on a beach, partying, working at the office, waking up and cooking at home.



**Figure 6** Co-design workshop tasks.

The second task was to ideate situations where the participants' music tastes differ most from their "usual music taste". As people's music taste often varies across different situations (Bull, 2008; Levitin, 2007; North, Hargreaves, & Hargreaves, 2004), we aimed at ideating situations that would result in non-obvious scenarios and use cases for contextual music. We asked participants to think about the factors that make them choose music for the situation and to imagine what kind of music services they would like to have in those kinds of situations. As in the first task, we asked them to describe the situations and motivations behind their choices.

For the two first tasks, participants first worked alone, then discussed the situations (scenarios) in pairs. After initial feedback in pair discussions, the situations were read aloud, followed with an hour-long group discussion for both tasks, moderated by the researcher. The third and final task was to

evaluate the initial concepts based on short verbal descriptions and visualizations. After a group discussion, feedback was gathered by writing.

The user workshop produced qualitative data in the form of researcher notes and video recording of the discussions, from which themes for the design principles were formed using the grounded theory approach (Birks & Mills, 2011).

The insights from the user data are summarized in the following: Users wished for recommendations that would suit their situation without requiring effort. According to user feedback, the services need to be unobtrusive and undemanding: they wished for a single application download and an easy one-time login. They also wanted to be surprised by events and content that would have just happened or were about to happen soon. Some of the users wished that recommendations should be generated by mash-ups of several data matching the user's current situation, for example weather, location, time or activity. Participants also desired to find location-music combinations and browse the musical histories and memories of different places, share them and create their own musical places on locations meaningful to them. User insights helped us greatly in formulating the design principles, presented in the next section. In the written evaluation, users saw Musical hotspots the most feasible, flexible and rewarding of the concepts. Based on this insight we implemented a variation of Musical hotspots for the field study as an urban culture festival recommender (Article II).

#### 4.1.2 First prototype design: Sounds of Helsinki

The underlying objective of the entire design and research process was that the services should augment the everyday urban experience by involving new location-based music interactions. This was the key *design target* (Vääätäjä, Olsson, Savioja, & Roto, 2012). A set of more concrete design principles was drawn from the current socio-cultural trends, expert discussions, user data from the first workshop and the previous research (Articles I, V). Design principles were formulated as:

- Context-awareness, specifically location-music combinations. We wanted to offer music that would sit right into the fabric of the everyday life.

- Mobile and ubiquitous use. The concepts and prototypes were created specifically for people on the move in urban environments, for example for filling urban breaks and excess time such as waiting for a bus or making the unavoidable commuting around the metropolis more tolerable, even enjoyable.
- User-created content. We aimed that users could make the city more their own by modifying it through attaching music and other content in meaningful places.
- Light and undemanding experiences that are unobtrusive to the users. For example, in the prototypes we offered push recommendations or easy scanning of the user's immediate surroundings by an AR interface for finding content.
- Living in the moment. We wanted to support the potential for quick decision-making enabled by mobile phones. For example, while moving in a city during their free time, people sometimes make decisions to attend an event or meet friends at the whim of the moment.
- Social sharing of experiences and content through social media.

Based on the insights from the workshop, a prototype was designed iteratively in the research team meetings. Following the evaluation of the user data from the early adopter workshop and weighing the technical resources against maximizing potential for rich user experiences and the research outcome, we decided to build an ad-hoc urban events recommender for a large-scale urban culture festival.

*Helsingin Juhlaviikot* festival takes place every summer for three weeks. It has hundreds of mostly music-related events spread over the city center and adjoining districts. The festival was ideal for a study of a mobile music and events app aiming for serendipitous discoveries. The prototype was designed so that whoever with a smartphone could use it by a mobile web browser. To receive quality recommendations users did not need to train the recommender at all, in contrast to many collaborative filtering recommenders that may need dozens of sessions before they offer genuinely new and

interesting items. In addition, the learning curve for the service use was very short.

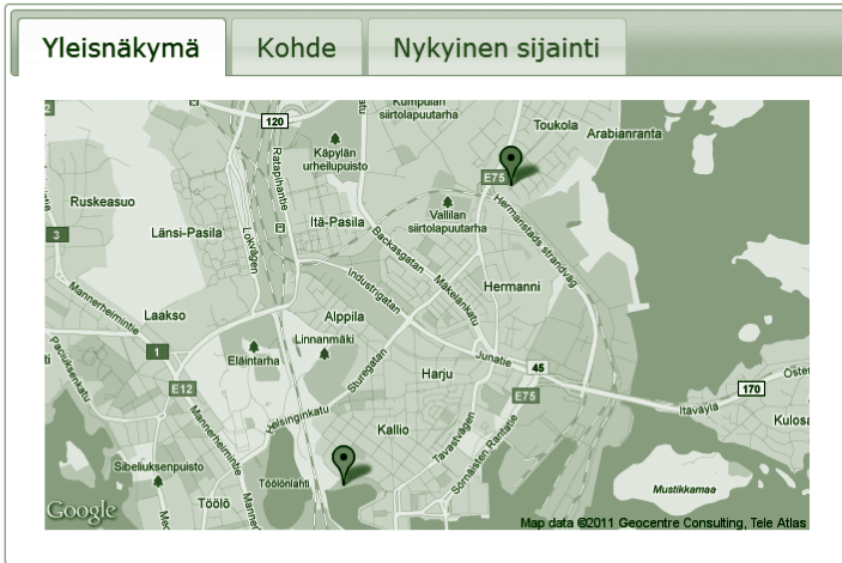
The prototype offered participants music and video clips promoting the artists performing at the festival while moving in the city. Users were sent notifications through a pop-up screen: “New recommendation!” By touching the pop-up window, the user entered the first view of the UI, which showed the name of the event or artist, the address and below, map scaled so that the location of the user and the recommended event location were presented as points on the map. UI also had two tabs for more accurate map views where the location of the user and the location of the event were presented on a bigger scale on the map (Figure 7).

## Fatoumata Diawara, Mad Ice

Huvila-telta (Tokoinranta) - arvioitu etäisyys 3.4 km

Tulevat esitykset:

to 25.08 klo. 19.00



Blue marker: event location; red marker: your estimated location.

Music sample - test:



**Figure 7** Sounds of Helsinki user interface.



In addition to the map view, we provided a media player for listening to a track or watching a video of the event-related content. Moreover, below was the text “did you like the recommendation?” with thumbs up, thumbs down function for gathering user assessment. Below that, a link to “all recommendations” was provided, which lead to the second view of the UI, the list of previously recommended events. Users could browse them and by clicking the links go to the player view to play the media content.

### 4.1.3 Field study

We performed the field evaluation of the first prototype during *Helsingin Juhlaviikot* festival for several reasons. Firstly, festival’s policy is to introduce international artists previously unknown to the larger public as well as well-known Finnish artists. This gave us a chance to study the prototype’s potential for producing relevant, novel and serendipitous recommendations from a diverse artist pool. Secondly, the festival lasts for three weeks, giving us an opportunity to offer recommendations for a great number of events happening on different days. Thirdly, the festival takes place in a broad area so the feasibility of recommendations could be evaluated according to the different locations, near and further to the events. Also, because the events are spread over a large area, festivalgoers are not necessarily aware of all the interesting gigs. Finally, recommendations were studied in the wild to evaluate their value not only for the users but for advertising and promotional purposes as well.

Fifteen early adopters participated in the field study. The participants were divided into two groups ( $n=7, 8$ ), using the prototype during consecutive weekends. Both groups were equipped with smartphones for using the web-based contextual recommender. The system sent 241 push recommendations, of which the participants checked out 89%. Recommendations were sent between 2 pm and 10 pm to match the recommendations to the users’ free time. Half of the recommendations were location-sensitive and the other half were random regarding the users’ location.

The system logged user responses to the recommendations. The users rated items using *thumbs up* and *thumbs down* buttons. In addition to up-down ratings, at the end of the field study, we collected responses to two questionnaires. The participants filled in a ten-item questionnaire of overall quality of recommendations and UX dimensions, adapted from a user-centric recommendation evaluation framework proposed by Pu and Chen

(2010). Participants were shown each recommendation again in a per-recommendation questionnaire. As in the overall questionnaire, the opinions were elicited by using a five-point Likert scale. The research is reported in the Article II.

## 4.2 **Second prototype: OUTMedia**

### 4.2.1 Concept design

The second design and research cycle started with the user interface. It was decided early on since we had the resources to explore with a non-standard UI, a mobile AR technology. This allowed us to shift our focus from not only offering location-aware but also location-sensitive (i.e. the content available only when on or nearby the location), intuitive to use and (quite literally) transparent user interface, which allowed the users to have access to the content through the smartphone camera. The concept was the second iteration of Musical hotspots concept, with new features that mimicked user-created content and social media connection.

### 4.2.2 User workshop

For the workshop, we invited eight users that regularly spend time during summer in the chosen city district renowned for its music venues, bars, parks and other summertime hangouts. In the workshop, participants were asked to mark potential places on the map printouts of the district in terms of a) sharing music, b) listening to music and c) receiving music recommendations.

The map exercise showed that favorite places clustered around four parks that we used as bases for the route of the field study. In a group discussion, participants were also asked to tell why they considered those places potential for music consumption. The points-of-interest (POIs) were later placed on the map and AR objects were created for those POIs for the service prototype that became OUTMedia, a mobile AR music discovery app (Åman, Liikkanen, Jacucci, & Hinkka, 2014; Article IV) (Figure 8). In other words, at each POI, an AR object was placed, consisting of a music track and user annotation.

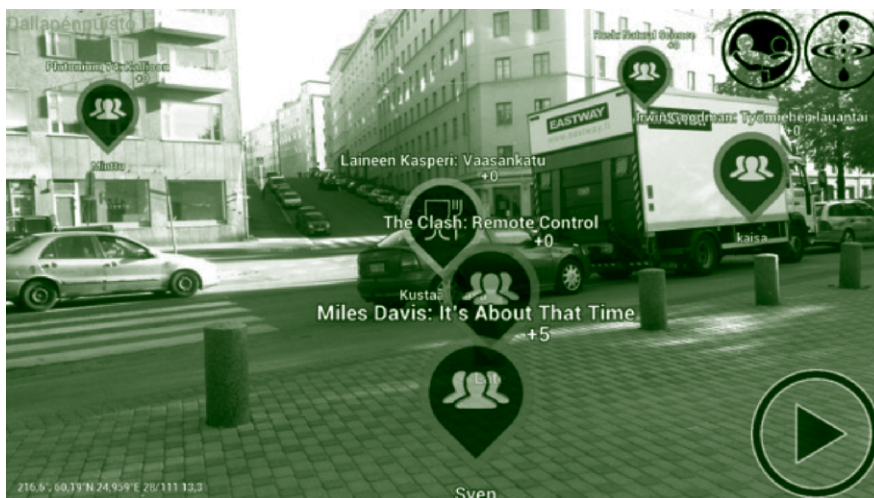


**Figure 8** Points-of-interest presented on the map of the field study district [Kallio in Helsinki, Finland].

#### 4.2.3 Design of the service prototype

The application allowed users to discover (locate and listen to) music in a city district through a mobile AR application (Figure 9). The prototype design is reported in more detail in the Article IV. The main manifestation of the added value to the user is *the revelation of hidden content, a layer of music*. The second aspect is *the identification and association of music with a location*, and third *the discovery of new music*. The exact locations for objects were gathered from the users in the workshop to ensure that the locations were relevant and coming directly from the users' everyday lives. Of the foundational concepts, the service concept resembled not only Musical hotspots but also had features from Musical treasure hunt as well (although without gaming features), in terms of discovering and choosing the most interesting

AR objects for listening and checking out the (optional) annotations other users had left.



**Figure 9** The main user interface of OUTMedia. Icons refer to the user created (heads) points-of-interest and ads by bars or restaurants (glass and a fork). In the right upper corner: Friend filter and Soundtrack of a place (see 5.2.1 and Article IV).

#### 4.2.4 Field study

In the field study, a prototype was employed for gathering insights about the feasibility of the service concept. For the field study of the second prototype, 18 participants were recruited. Most of them had participated in the earlier workshops and in the field study of Sounds of Helsinki.

We wanted to study the potential of an AR application for promoting serendipitous location-based music recommendations in a realistic context. Therefore, we chose to conduct the field study in a multicultural city district with a high density of music venues, bars, restaurants and summer outdoor hangouts. The density of music-related places made the district ideal for the field study since we could plant over one hundred AR objects along the route in a believable manner, mimicking a real service and thus resulting in a modified Wizard of Oz study (Klemmer et al., 2000). In our case, Wizard of

Oz meant that the prototype was semi-functional, having a limited amount of AR objects and limited social media functionality. A researcher walked the route with a single user at a time, stopping in four parks along the route and guiding the participants in each park to freely use the application, to scan their surroundings for AR objects, listen to the songs and interact with the app.

User experience was evaluated using a combination of methods that included analyses of interviews, group discussions, log data and questionnaires. Both application prototypes logged user interactions and system statuses regularly while there was no interaction. The user interactions were recorded with a timestamp. The log data was processed with Microsoft Excel and analyzed with SPSS.



**Figure 10** OUTMedia prototype use in the Kallio district public park.

After the field study, users completed a three-part questionnaire. The first part included questions adapted from the Recommender systems' quality of user experience instrument (ResQue) (Pu & Chen, 2010). The second part evaluated the understandability of the UI elements and in the third part, the user preferences about the different recommendation categories were gathered. Participants were also interviewed after the experiment along 12 themes that evaluated the service prototypes' acceptability and UX, and the perception of various AR media types.

The user study showed that we succeeded in supporting personal meaning-making with a virtual layer of user-created media (music, text) and place combinations, and thereby enriching the urban experience. The field study was reported in the Article IV.

### 4.3 **Methods, data, users and design artifacts**

The methods, user involvement in different phases, design artifacts and data types are illustrated in Figure 4 (see p. 33). Through the course of the prototype development and evaluation, the primary data-gathering techniques were individual interviews, focus groups, data logging, and questionnaires. *Interviews* followed a semi-structured protocol. The benefit of conducting semi-structured interviews was the flexibility of the interview situation. If there was a need to ask for clarification, add questions or follow interviewee's comments, the semi-structured format gave space for that (McCracken, 1988). The semi-structured approach allowed for exploring the topic in depth while framing the topic with a handful of chosen themes.

In the field studies, we used *data logging* to acquire objective, quantifiable data that could be combined with subjective qualitative data gathered in interviews, questionnaires and focus groups. In Sounds of Helsinki, user interactions and offered recommendations were logged. In OUTmedia, user interaction data was logged, together with system status data.

*Questionnaires* adopted from the ResQue instrument (Pu & Chen, 2010) were used in both field studies to collect data on user experience and subjectively perceived recommendation quality (for the actual questions, see Articles II, IV). Questionnaires were administered after the field studies. The questions were comprised of multiple-choice and Likert-scale questions where users selected their level of disagreement or agreement for a series of claims. *Focus group* discussions were used in user workshops to ideate and evaluate service concepts.

*Qualitative* data analysis followed the principles of grounded theory (Birks & Mills, 2011): hypotheses were not formed before the research and themes and theoretical constructs were formed from patterns from empirical data. *Quantitative* data was analyzed with SPSS and presented using several statistical techniques. In the design and research process, altogether 37 early adopters of online music services were involved in iterative design cycles. From the pool of users, 8 to 18 were involved simultaneously in the different

phases. I agree with Heiskanen, Hyysalo, Kotro, and Repo (2010) that more user involvement is not necessarily better. Users do not necessarily have inherent ability to contribute (positively) to the design process. Instead, designers or researchers must facilitate the ideation and evaluation of concepts and these activities can flourish with careful planning of the interactions with the users. To succeed in the collaborative design process with the users, the following topics must be addressed (Heiskanen et al., 2010):

1. How knowledge sharing between users and producers evolves?
2. What artifacts can serve as mediating representations?
3. What challenges there are to aligning differing interests?

We opted for involving early adopters of new music services variably throughout the process. In our case, participants provided inspiration and end-users' point of view. They were not designers of the system in the way von Hippel (1986) presents the users' role in a collaborative design process. For example, our users did not write code. They can be called *early adopters* of technology (Rogers, 2003). Our approach resembles "resonance testing", an industry method for concept testing, in that it is a lightweight method of eliciting user responses to the design concepts and move forward in the design process quickly (Liikkanen & Reavey, 2015).

The design process of a virtual hangout Habbo Hotel ([www.habbo.com](http://www.habbo.com)) serves as an example of a successful co-design process where the social proximity of the designers and users the crucial factor, not the amount of interaction (as discussed in Johnson, 2010). In the early days of Habbo, interests of users and designers were often very similar, and most of the designers involved in the development process were also active users of the service (Johnson, 2010). In our case, user involvement in the right phases of the process and with the right methods were the most important choices.

We focused on people who actively seek new music, films or other entertainment, and can be described as early adopters of mobile digital media services. These users actively consume digital content on the move, e.g. use music for mood regulation when commuting or exercising. Studying the heavy users and early adopters of ubiquitous technologies has certain advantages: Contextual media recommendation services are still largely unexplored area and there are no major commercial successes yet. Furthermore,

early adopters often have needs and desires that current markets cannot satisfy and therefore, they come up with innovative solutions to fulfill their needs (von Hippel, 2005; Rogers, 2003). From the “mis-use” and creative appropriation of technologies by early adopters, potential future uses of technologies for the user majority may be extrapolated. Also, early adopters are commonly technology enthusiasts and thus have a strong motivation to commit themselves to the design process. Working together with a pool of users through various methods and design artifacts had a strong impact on the choices made throughout the design process.

We found that gathering user data before prototyping had several benefits, such as getting quick feedback on the service concepts and gathering user opinions about which design features would really work in the realm of the everyday life. Changes in the course of development are easier to execute before presenting a working user interface, which would direct the user opinions more heavily (for discussion on levels of representation, see Liikkanen & Reavey, 2015). One of the central benefits of modern UCD and HCD is embodied interaction (Dourish, 2001) through physical, tangible objects, be it games, paper prototypes, maps or functional prototypes. When planning design artifacts and tasks for users, special attention to the quality of the interaction between researchers and users should be paid, so that users find the interaction to be motivating and rewarding.

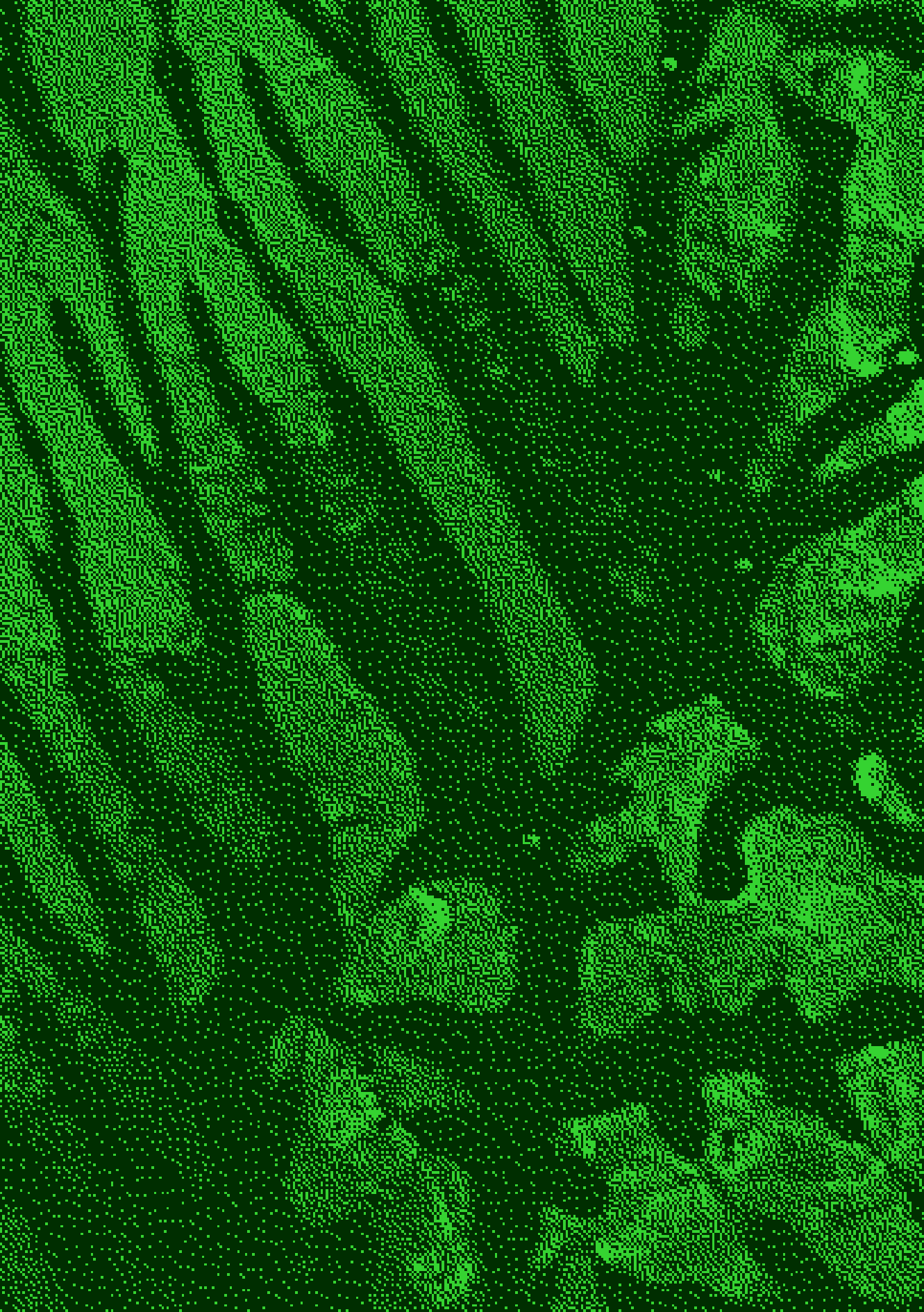
As a conclusion to the presented methods, users, design artifacts data, by involving the right kind of *users* in the right *phases* of the research and design process with the right *amount of intensity* and with the right kind of *methods* and *design artifacts*, it is possible to design feasible service concepts and evaluate them in real-life settings with relatively limited resources.

#### 4.4 Summary

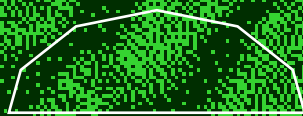
In this chapter, I have summarized the design and research process of two prototypes. I conclude by reflecting the ways in which the different views on context (presented in Chapter 2) realized themselves in the different phases of the design and research process. In the design process, we chose certain contextual information types as being necessary in order to provide a well-designed UX for location-sensitive music discovery in an urban context. Dey and Abowd’s (1999) view in its unequivocalness was useful for mapping out the context types. Later, in the design process, we



applied openness and adaptability, for example letting the users choose what kind of content users could leave in the locations, allowing them to “negotiate and evolve activities, practices and meanings over time in interaction with information systems” (Dourish 2001, 14), and contrast user-created content against curated content (of which the former was more unexpected, serendipitous and preferred in the field studies). From the interview data of *OUTmedia* field study, we found out that users gave a wide variety of meanings to app’s features. The semantic interplay between different media content, together with places, enabled open meaning-making processes while using the application, just as Krippendorff (2006) describes in his semantic view on context. Our process exemplifies that each of three views on context is useful and has its place in the different phases of the design and research process.



# 5 CONTRIBUTION: KEY THEMES, FINDINGS AND DESIGN IMPLICATIONS



In this chapter, I summarize the key themes, findings and design implications of the research presented and reviewed in the Articles I–V. They answer my research question from various viewpoints:

*How to design serendipitous, rewarding and enjoyable concepts and interactions for contextual music recommendation and discovery?*

The themes, findings and implications reflect the levels presented in the model of UX for contextual music recommendation and discovery (Table 3).

1. Content quality	2. User interface	3. Context factors	4. Concept level
Relevance	<b>Interaction adequacy:</b> <i>Minimizing user effort</i> Presentation <i>Transparency &amp; explanations</i> <i>Multifunctionality</i> <i>Serendipity</i>	Location	<i>Open meaning-making</i>
Novelty		Time	
Serendipity		Identity	<i>Experiencing places</i>
Reach		Activity	
Diversity		<i>Serendipity</i>	<i>Serendipity</i>

**Table 3** The model of contextual music recommendation and discovery UX. 1.–4.: The levels of UX; in columns, properties evaluable by users or experts, of which the key themes presented in this chapter in italics.

Of the USER INTERFACE level themes, I present findings on *minimizing user effort*, *transparency and explanations*, and introduce the term

*UI element multifunctionality* in the first three sections (5.1–5.3). They are dimensions of interaction adequacy, a construct adapted from Jones and Pu (2010).

The CONCEPT level themes of *supporting open meaning-making* and *experiencing places in the city* are addressed in 5.4.

The key findings on SERENDIPITY are presented in 5.5. The data from the field studies of Sounds of Helsinki (Article II) and OUTmedia (Article IV) showed that the overall user perception of serendipity as a *content level* combination of novelty and relevance was simply found positive by most of the users. Therefore, the data is not represented here (see Table 4). The main focus is on serendipity triggered by *context factors*, but I also present findings on *concept and UI level design decisions* supporting serendipity.

DESIGN IMPLICATIONS are presented at the end of the chapter (5.6). A summary of the themes addressed in the articles and selected for presentation is presented in Table 4. I start each section by introducing a theme and summarizing the relevant previous research on it, before presenting my contribution.

## 5.1 Minimizing user effort

Reducing the user burden by sensing the user's context and suggesting tailored recommendations suited for the situation is one of the central benefits of contextual recommendation (Adomavicius & Tuzhilin 2015; Ricci et al., 2015). Minimizing the user effort is also a more general level UI design principle. Minimalist design aims at simplifying UIs by getting rid of interactions, UI elements or content that does not support user tasks (Meyer 2015a; Meyer 2015b). For example, offering a continuous stream of music requires less user effort than choosing and playing one music track at a time.

I present five strategies that worked well (Articles II, IV, V) for minimizing user effort for contextual music recommendation:

- Proactive versus reactive recommendations
- Ad hoc recommendations, tailored right to the situation
- Implicit versus explicit context information acquisition
- Minimal or no preference elicitation
- Short learning time for the systems' main functionalities

Article	I Review: trans- parency & explanations	II Sounds of Helsinki prototype	III SoundAbout platform	IV OUTMedia prototype	V Review: contextual music recom- mendation systems
Level					
<b>Concept level</b>	None	Serendipity	None	Open meaning-making Experiencing places Serendipity	Serendipity
<b>Context level</b>	None	Location, time	Location, time, identity	Location, time, identity	Location, time, identity
<b>User interface level</b>	Transparency & explanations Minimizing user effort	Transparency & explanations Minimizing user effort	None	Transparency & explanations Minimizing user effort Multifunctionality	Transparency & explanations Minimizing user effort Multifunctionality
<b>Content level</b>	None	Results in Article II	None	Results in Article IV	None

**Table 4** Summary of the themes and findings presented in Chapter 5.

Before presenting my contribution, I set the scene by summarizing some of the previous research on the above five strategies.

In the music recommendation domain, several researchers (Ankolekar & Sandholm, 2011; Celma, 2010; Reddy & Mascia, 2006; Schedl et al., 2015) discuss *user effort* in the cases of creating an initial user profile manually, providing user preferences, giving the system feedback of the recommendations, and in the case of explicit context information elicitation, stating that in all these cases the required user effort should be minimized. Guidelines for preference elicitation in relation to optimizing the required user effort are provided by Pu, Faltings, Chen, Zhang, and Viappiani (2011).

The conceptual pair of *push and pull* recommendations (Mahmoud, 2006; Ricci et al., 2015) is closely related to the required user effort. Push refers to recommendations that are offered proactively, without an explicit request (e.g. push notifications). In a pull model, recommendations demand deliberate user interaction. The majority of recommenders developed so far follow the pull model (Ricci et al., 2015).

Today, mobile devices are often the main channels for accessing online content, including music (Liikkanen & Åman, 2015). In addition, modern phones typically have over twenty sensors. Therefore, it is becoming easier to offer *proactive* recommendations that exploit various contextual dimensions and provide recommendations based on them, requiring less user effort than traditional recommendations following the pull model (Schafer, Konstan, & Riedl, 2001; Woerndl, Huebner, Bader, & Gallego-Vico, 2011). The previous research on proactive recommendations has been conducted for example in the domains of mobile advertising (Bulander, Decker, Schiefer, & Kolmel, 2005; Mahmoud, 2006) and ubiquitous shopping (Sae-Ueng, Pinyapong, Ogino, & Kato, 2008).

Proactivity relates closely to the recommendations that are tailored to fit the current moment. One of the promises and advantages of contextual recommendation systems over traditional ones has been their ability to provide “live” or ad hoc recommendations for the current situation (Adomavicius & Tuzhilin, 2015; Gorgoglione, Panniello, & Tuzhilin, 2011).

*Short learning time*, or learnability, is a common usability goal (on the relation of learnability and usability, see Mifsud, 2011). In the context of e-commerce recommenders, Pu et al. (2011) refer to user effort as the time it takes from the user to finish an instructed action. Jones and Pu (2007) conducted a user evaluation of two music recommenders (*Last.fm* and *Pandora*). They found that for novice users, it took several minutes to register

and start to receive recommendations, thus revealing a feature in the systems that could easily be improved by more careful design. In the next paragraphs, I will address the contribution on minimizing user effort in my research, showing, for example, that the systems presented in Articles II and IV required very little effort to start receiving recommendations.

Sounds of Helsinki was the first published prototype (Article II). It did not require any preference elicitation by the user and its learning time was short, giving it an advantage over the most existing music recommenders (e.g. Pandora, Spotify's recommendation features) that either require the user to give preferences or train the system by using it for a certain period of time. The system sent a push recommendation with the user's location triggering the recommendation about a music event that was going to happen soon near the user. The UI view showing the recommended event was opened automatically. The user could see a map showing the user's location together with the event location and the accompanying music track to decide whether to go (Article II). This conveys a specific advantage over pull recommenders: the system applied context factors to advertise events, reacting in real time to the users' changing situations.

From a technical point of view, by reacting real time and without previous user interaction or preferences, contextual recommendation systems can help in overcoming the known recommender issues of *cold start*, *popularity bias* and *collaborative filtering feedback* (as discussed in 3.3).

In the second prototype, OUTmedia (Article IV), users browsed their surroundings through an AR interface, where the objects containing the user name and track title were presented floating on the screen over the realistic camera view. Tapping an object, the player view opened. Beyond common player functions, the player view had presented a timeline of the music track and a "Favorite" button. A time stamp, annotation and username were also shown.

OUTmedia applied four of the five of the design strategies listed above, only leaving out push or proactive recommendations. The prototype offered ad hoc recommendations that were based on the user's location and there was no preference elicitation. These design strategies allowed the users to discover new music more easily than by using most of the existing recommenders. For example, Pandora requires the user to provide a seed artist for starting each new personalized "radio station". Spotify recently released a feature, "Discover weekly" that pushes every week a personalized list of music tracks, based on the user's all-time listening habits within the service.



However, other aspects of OUTmedia may make it harder to receive recommendations when compared with traditional music recommenders, for example, a user must be in a certain place to browse the recommendations. This was a deliberate design choice in order to offer a new kind of music service for urban environments, as discussed in Section 5.4.2.

During the field study, we observed a privacy issue due to people being unfamiliar with mobile AR. Some by-passers were disturbed as they thought our users were capturing video of them. In the future, increased familiarity with mobile AR may provide a solution to privacy issues in public spaces. If an AR interface is included in an everyday object such as eyeglasses (e.g. Google glass), there most certainly will be social clashes before AR becomes an everyday technology.

In the review article (V) on contextual music recommendation research prototypes, we pointed out that often the purpose of adopting contextual factors is specifically to minimize user effort. Particularly, in the systems that provide a stream of music based on context factors, the application usually gathers context data implicitly and gives recommendations without user effort, proactively, updating the playlist of music stream as the context changes. These “automated” systems (see Article V, Section 3.2) are often designed for a certain activity, such as sports or car driving. In these systems, required interaction is typically minimal, so that the main activity can continue uninterrupted. Most of the existing commercial music recommenders do not react automatically to the user’s changing context. Instead, if different music is required for a certain situation, it must be hand-picked and saved as a playlist for that particular situation (e.g. running, studying)

Summing up, there are several ways to minimize the user effort by a) involving context factors in the recommendation and discovery process and b) by following general usability principles for making the system use easy and enjoyable to use.

## 5.2 Transparency and explanations

Explanations can serve several purposes, for example providing transparency, persuading the user to try or buy an item, help in building trust towards the system, or telling the system its recommendations are undesirable (Tintarev & Masthoff, 2015).

In article I, we reviewed explanations in six commercial online music

systems and found that systems were typically “black boxes” with very limited explanations. We also made a distinction between three kinds of UI elements: textual, visual and interactive. Recommenders have traditionally communicated transparency and explanations by text.

In Article V, we reviewed 19 research systems of contextual music recommendation and discovery and found that the systems mainly relied on standard UI solutions for interacting with context factors and providing transparency and explanations for the users. In comparison with the commercial systems, explanations were more common in research prototypes, although through generic text-based means.

Two key themes emerge from the articles (I, II, IV, V):

- Visual and interactive UI elements can be used as alternatives or replacements for providing transparency and explanations beyond text, the traditional way.
- Context factors are able used to provide transparency and explanations in multiple ways.

### 5.2.1 Transparency and explanations beyond text

In the Articles I and V, we argue that features applying interactivity, visualizations or both of them can replace textual explanations and serve the same functions, often in more rewarding ways. By involving interactive UI elements, for example in the form of conversational UI offering the user multiple options for a recommendation goal (see Article I, Figure 3) may provide an improvement for existing music recommender UIs. However, in most cases, textual explanations would be better than no explanations at all.

OUTmedia (Article IV) utilized a visual and interactive means for transparency by the “Friend filter” feature that showed by a simple single button interaction a simulated view of the music objects browsed by the users’ social media friends (Figure 11).

The advantages of visual and interactive explanations are further illustrated by Gretarsson, O’Donovan, Bostandjiev, Hall, and Höllerer (2010) who studied visualizing all available items of a database (of scientific articles). The authors highlight how their visual interactive interface is able to not only produce accurate and transparent recommendations but also helps in

learning quickly about other users' preferences, which would be hard using textual explanations for such a great number of items.



**Figure 11** Friend filter off (top), and on (below), showing only objects that the user's friends have browsed.

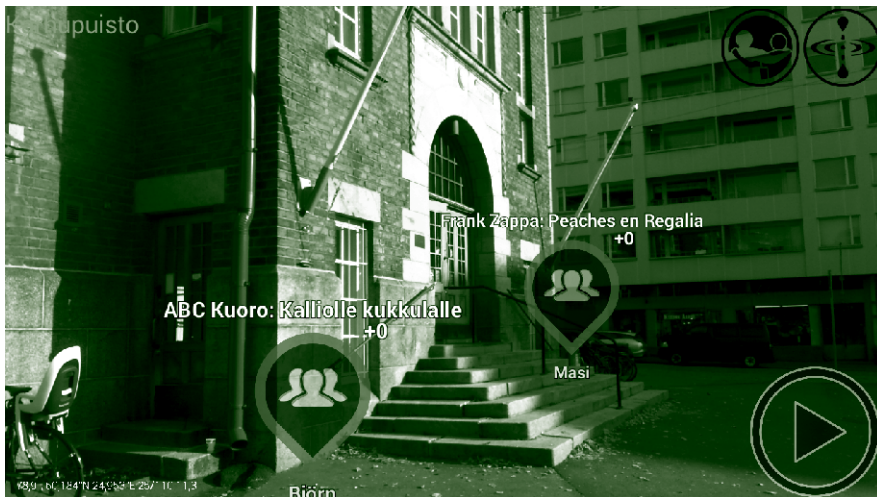
Music recommenders typically offer explanations such as “you listened to Prince, try a similar artist Wendy & Lisa”. However, compared with text, visualizations or interactive elements are able to tell the user more efficiently



(e.g. at the start of the use), they should be communicated when presenting recommendations to the user.

Location, the most commonly used context factor is typically used for showing the geographical site of the recommendation, as in the music recommenders by Lehtiniemi and Ojala (2012) and Ankolekar and Sandholm (2011), or in the mobile shopping recommender by Laches, Riedl, Hauptmann, and Woerndl (2015). Although there are several context-aware music recommenders (see Article V), there is little research discussing context factors applied as *explanations*.

Mascia and Reddy's (2006) contextual music recommender had a UI feature applying an audio equalizer metaphor. Using the sliders, users could adjust how much the different context factors affecting the recommended music to be played next. By displaying the context factors currently affecting the recommendations, the system provided transparency by reminding the user why a specific song was being played in a certain situation.



**Figure 13** Two songs attached to a public library building, the big size of the objects showing the close proximity.

As with traditional recommendation systems, transparency and explanations of recommendations have a key role in contextual systems. Sounds of Helsinki (Article II) applied context factor location to reveal the system logic through an interactive feature, a map telling that an item was recommended

because of the user's close proximity to the content. Several commercial music apps (e.g. Tunaspot, Uncharted) have used map-based mash-ups of music and location, but slightly surprising, there are no commercial breakthroughs yet.

In OUTMedia prototype, a mobile AR interface was adopted in order to show the user the transparency between the user's location and the recommended music. The interface showed both the distance and the direction of the music object (Figure 13). In both prototypes, another context factor, time, was presented to the users as numerical values. Context factor identity was presented as a part of the augmented objects layer in OUTMedia by showing the user's name with the AR object.

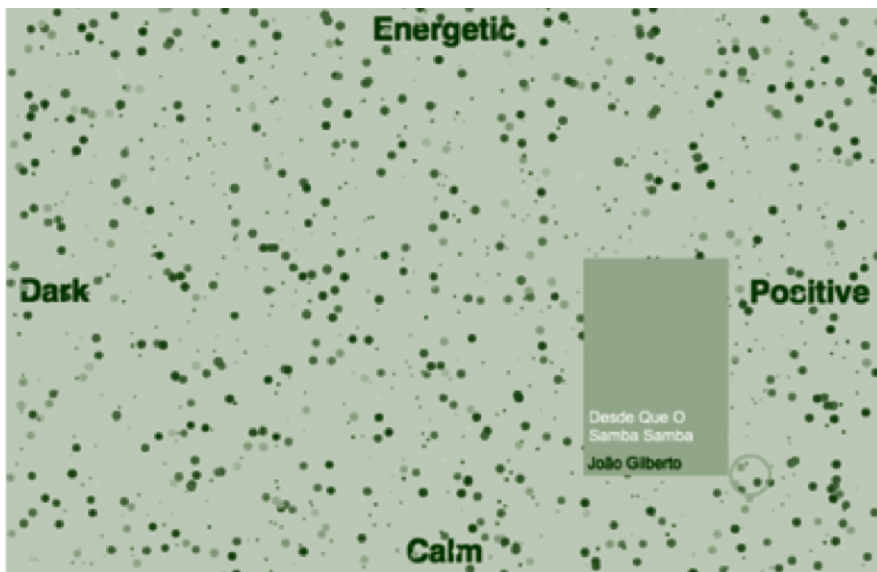
Systems that in Article V are called "automated" typically aim for an unobtrusive UX by acquiring the context data implicitly and providing the user with an automatic stream of music tailored to the situation. They usually adopt multiple context factors in an all-inclusive, systemic approach, aiming to cover the user's situation in a complete way. Interactions are typically minimal so that the user can go on with her activities uninterrupted. Automated systems typically do not tell the user why a song was recommended. While the music stream without explanations may result in an enjoyable and effortless UX while involved in an activity that occupies hands or eyes (e.g. car driving or jogging), providing users with some transparency through a widget or visualization could result in an even better UX.

### 5.3 UI element multifunctionality

As various UI elements (text, visual, interactive) can function as transparency and explanation facilities, a single UI feature can fulfill several functions of interaction adequacy. I call this UI element *multifunctionality*. Although there are many systems with UI features that take care of several functions through a single widget (for the contextual music recommendation domain see Article V), I am not aware of any previous research addressing the use or advantages of multifunctionality of UI features. The advantages of using a multifunctional UI feature are twofold: by combining several functions in one widget, efficient user interaction as well as economic screen space use can be promoted, specifically in mobile applications. Beyond providing transparency, multifunctional widgets can help in minimizing user effort, presenting music tracks and allowing user feedback.

Examples of multifunctional interfaces from the original articles include OUTMedia (Figure 9), The Compass (Article V, Figure 3) and Lifetrak's Contextual Equalizer and (Article V, Figure 8). I will return to the serendipity-enabling dimensions of Contextual Equalizer and OUTMedia AR interface in Section 5.5.

Commercial online music discovery tool Musiccovery (<http://musiccovery.com/>) has an interface including a board (Figure 14) with four common moods revealing music tracks as the user moves the cursor across the board. It shows how different goals can be promoted by a single multifunctional UI element. The interactive visualization reveals the reason why a certain piece of music was recommended (e.g. calm and positive music) and at the same time gives a user a tool to refine the search easily. While user effort is kept minimal, the UI does not present the tracks clearly: they are shown only when moving the cursor, however, allowing unexpected discoveries.



**Figure 14** Musiccovery's multifunctional music discovery board.

By adopting interactive timelines or visualizations, users can browse content by histories of use, places, users and activities. Timelines or other visualizations are able to fulfill the functions of many or even all of the dimensions of interaction adequacy (user effort, transparency, presentation,

refinement). Utilizing a slider for browsing music tracks by the release date serves as an example of a potential time-based concept for music discovery. The slider would give the user an effortless refinement aid and at the same time, it would tell why the items are presented to the user.

Summing up, in many cases, a more rewarding UX can be promoted by applying non-verbal UI elements as “implicit” explanations. For example, a visual map can be provided if the users have enough cultural capital (e.g. about a genre) and therefore are able to “join the dots” between the recommended items (e.g. tracks belonging to subgenres within a genre) without explicit textual explanations. If a recommender is used for learning about a genre not familiar to the user, textual explanations, combined with a map showing relations between artists, could work better (Article I).

In the following section, I will move from the UI level to the themes, findings and implications regarding the overall service concepts.

## 5.4 Concept level themes

In Article III, we envisioned a platform that would allow people to “paint the city” with music. We saw this practice similar to graffiti painting although in a more discreet manner. “Invisible graffiti” could be used to create and share location-aware virtual, aural layers in the city while roaming around the city in the spirit of a belle-époque *flâneur* (Baudelaire, 1995) or Situationist *dérive* (Debord, 2006). These inspirational principles were applied as guides in the prototype design process. I highlight two themes discovered in the OUTmedia user study (Article IV) through a grounded theory approach:

- Supporting open meaning-making
- Experiencing places in the city

Before presenting the contribution, I briefly review the previous research on contextual music prototypes that support open meaning-making or allow people to experience urban places through music. We conducted an extensive review of the previous contextual music recommendation and discovery prototypes (Articles IV, V). Most of the reviewed systems (16 out of 19) applied location to their music recommendation and discovery



concepts and location, time and identity (usually implemented as a social media feature) was the most common combination.

By open meaning-making (Article IV) I refer to the users actively constructing meanings as interplay of associations triggered by places, music and user annotations. This happens through subjective and social processes with the help of contextual services. None of the earlier studies on contextual music services explicitly speak about “open meaning-making”, but some of the systems have clearly enabled personal, open meaning-making through music, while their main purpose was to provide new kinds of place-related experiences in urban settings.

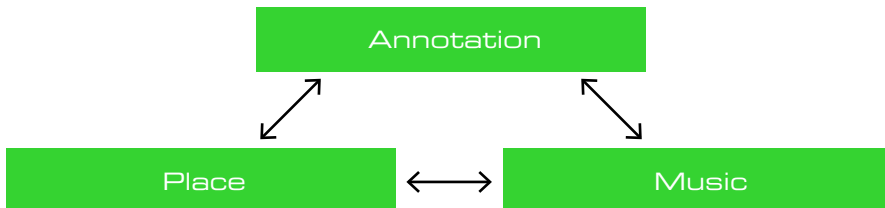
These systems include Foxtrot (Ankolekar & Sandholm, 2011), which helped the users to create their own meanings for the places through music by offering a radio-like stream of music attached to places, ambient sounds and user comments. PlayingGuide (Braunhofer et al., 2011) offered new dimensions to the city by attaching music to buildings, statues and other travel-related points-of-interest. Lehtiniemi and Ojala’s (2012) results show that users found it interesting to experience places through music that was attached to the areas by circumnavigating and thus “conquering” them. Their musical outdoors gaming app also supported experiencing places through time by the possibility to follow how the areas tagged with music evolve over time in terms of “ownership” and the music attached to them.

#### 5.4.1 Supporting open meaning-making

One of the most important findings of my work was to discover that using OUTMedia prototype resulted in experiencing time, places, and media content in novel ways, for example the AR objects were catalysts for various personal meanings through the interplay between location, user annotations and music (Figure 15). Each element of an AR object (user created or curated text annotation, music and the place where the music and text were placed) anchored meanings that varied much, depending on the user’s personal history, music taste, the style of the annotation, and so forth.

Another important finding was that the users preferred objects created by other users over the promotional ones since the user annotations were often non-obvious, offering unique interpretations of music or a place and therefore providing personal associations and more open meaning-making. This is in line with the fact that services that support freeform content

creation, sharing and interpretation (e.g. Facebook, Instagram) have proven to be successful.



**Figure 15** The associative interplay between places, user annotations and music. Each of three elements is capable of triggering a meaning-making process.

Although some of the users stated that visual content in the form of photos or videos could bring added value, some users commented that music and annotations are enough for creating rich personal associations with the place. In these kinds of services, a design choice must be made whether to include visuals, since music is more abstract than visuals and associations may therefore form more freely if no visuals are included in the service. Furthermore, the user opinions show that by providing a service that uses audio as its main content may lead to a fresh UX in today's visually dominated media culture.

#### 5.4.2 Experiencing places in the city

Location was the most prominent context factor in the prototypes we created. This section presents my contribution regarding location-related findings from the user research (Article IV) and the review of contextual music recommendation research prototypes (Article V)

#### **Location-sensitive media as “extensions and restrictions of man”**

Location-*awareness* refers to systems that apply context factor location in general. Location-*sensitivity* is a narrower concept, referring to a restrictive

access to content: it can be accessed *only* when the user is nearby or on that particular location.

Unlike most of the online content, which is available from everywhere and anytime, OUTmedia (Article IV) users had to be nearby or at the place where the content had been placed. Our user data shows that many users enjoyed context-sensitivity and its restrictions. We observed this *positive restriction* through Marshall McLuhan's (1964) concept of "media as extensions of man". McLuhan saw media as technological extensions of the human body and its senses. For example, telephony provided an extension for hearing. In the same vein, the Internet can be seen as an extension of multiple human senses. In the interpretation of the data, we expanded McLuhan's concept of "media as extensions of man" to "media as extensions *and* restrictions of man". This alteration of the concept was useful for our work in two ways: as an analytical tool for explaining the user responses to the location-sensitive prototype and for providing design implications.

While our application is an extension of human senses, the place-music-text combinations were accessible only when at or nearby the location. This positive restriction can be used as a design principle in contextual music and in other media applications. Another example of a positive restriction would be to let the users access content only during a certain time window for emphasizing the excitement of a live event and its real-time feel. See Snapchat ([www.snapchat.com](http://www.snapchat.com)) for an example of a service that allows users to post multimedia messages that are accessible for a limited period of time.

### **Supporting "right here, right now" functions**

Due to AR's location-sensitiveness, OUTmedia offered an added twist to the "status-checking practice" (studied by Oulasvirta et al., 2012). We expanded this practice by offering it as enriched "live feel" by including location information, thus enabling not only the time-based discovery of "what's going on right now", but also "what is going on right *here*". The users felt that the ability to spontaneously scan their surroundings for promotions, live events and specifically, user-created AR objects gave them a means to explore the district in a way that radically differs from traditional maps or map-based mobile city guides.

## **Experiencing place through time: supporting the accumulation of layers of urban cultural experiences**

In Article III, we envisioned a mobile service that people could use for experiencing music coupled with different locations, for example by seeing what music has been lately listened to in the various locations and districts of the city during a certain time span. We involved the concepts of psychogeography (“how a place feels”) and invisible graffiti to describe the characteristics of these kinds of services. According to our concept of location-aware music as invisible graffiti, music adds transitory cultural layers to a place. Those place-music combinations would evolve, change and fade over time to be found by other people, resulting in a city scattered with sound (Article III, p. 12). OUTMedia was designed to support these functions.

According to OUTMedia user study results, many users felt that by exploring the AR objects, they could experience the mentality of the place and part of its cultural history in new ways, whether they were familiar with the place or not. They perceived the AR interface as a geographical social media timeline, and accessing music-text-place combinations accumulated in the places enriched their experience of the place.

Our findings are in line with Paay and Kjeldskov’s (2008) results on their location-aware prototype for experiencing urban environments. Studied through video material, interviews and affinity diagramming, their users reported that experiencing a place through time by seeing what had happened on a location earlier enriched their experience of the urban space, for example bringing about a sense of historical continuity. These kinds of services clearly have the potential for enriching and augmenting urban environments with self-made and shareable layers of cultural content.

Summing up, the findings of user studies and reviews of the earlier systems showed that by adding location, together with time and identity as context factors in ubiquitous media services it is possible to enrich everyday living in urban environments.

### **5.5 Enabling serendipity**

Serendipity is first and foremost a user-perceived dimension (Adomavicius & Tuzhilin, 2015; Celma, 2010). Furthermore, all levels of UX

can trigger it (Articles IV, V). Therefore, it is hard to analyze which UX level (see Table 3) triggered serendipity in each case a user expressed experiencing it. However, designers can promote serendipity by many different ways. It may be triggered by a UI functionality that allows unexpected discoveries; it may be enabled by the whole service concept targeting to avoid offering only familiar and popular music; or simply by the user listening to random music for example on a radio and encountering a track that she experiences as unfamiliar and relevant. However, I will not represent the content level findings from our user studies in detail since the results simply prove that the content was found serendipitous by most of the users (see the results in Articles II, IV).

Finding serendipitous music is a common use case in music recommendation research (Celma, 2010; Herlocker et al., 2004; Ricci et al., 2015). It is usually supported by well-designed algorithms and maybe at its simplest by offering the user a random playlist (Leong, Vetere, & Howard, 2012). Instead, I have tried to support serendipity mainly with context factors (Articles II–V). Modern mobile user’s situations change constantly and that opens up the potential for unexpected encounters with media, places or other people. Context factors are usually involved in recommendations by measuring the variable conditions of the mobile device and its user and deploying the data for offering recommendations.

Followed by a brief review on the previous research on the topics at hand, I present two themes on serendipity from the field studies (Articles II, IV) and the review of contextual music prototypes (Article V) under Section 5.5.1:

- Context factors and context-sensitivity enabling serendipity
- UI multifunctionality enabling serendipity

Recently, recommender algorithms have been successfully designed not only to produce accurate recommendations, but serendipitous ones as well (Zhang, Séaghdha, Quercia, & Jambor, 2012). Context factors can also enable potentially serendipitous music experiences: “Since music can be connected to places in an arbitrary fashion, location-aware music services have great potential for providing serendipitous encounters with media content” (Article IV, 168). However, only two (those were my own work) of 19 articles on contextual music research prototypes reviewed for Article V mention serendipity.

In the user data gathered for Article IV, we found that the context-sensitive and therefore restrictive access to content often brought positive surprises to the users. One of the promises of the networked digital media has been its ability to overcome the restrictions of space and time (Negroponte, 1995; Weiser, 1991). Contrary to this strategy, applied by the majority of online content services such as Netflix, YouTube and Spotify, our findings turn this upside down. There seems to be a niche of users who appreciate getting access to content only on location and saw this as a fresh approach.

While I am not aware of any research using the term context-sensitive as we do in Articles IV and V, there are some earlier music research prototypes that involve context-sensitivity. These are mainly systems that apply nearby people or devices for music discovery in real time (reviewed as “collocated systems” in Article V).

BluetunA (Baumann, Jung, Bassoli, & Wisniowski, 2007) was an early mobile phone app for sharing music information with people who are within the radius of a Bluetooth connection of the user’s phone. Its potential for serendipity lies in the arbitrary nature of the connections made between people and their music information in densely populated urban situations such as subway trains and stations. The Compass (Tanaka, Valadon, & Berger, 2007) applied a compass needle UI for showing the direction and distance of other people, whose music could be downloaded. The authors state that their aim was to provide an alternative to a defined geographical map and allow users to wander and stray (Tanaka et al., 2007). The system clearly has a potential for serendipitous encounters although the authors do not mention it.

User evaluation results show that the users appreciate the serendipitous aspects of the collocated systems. For example, Push!Music (Hakansson, Rost, Jacobsson, & Holmquist, 2007) allowed users to find nearby people and send and receive music files. The anonymous and socially agnostic (i.e. not differentiating between friends and strangers) social interaction of Push!Music was perceived positively as the users described receiving previously unknown music as unexpected “treats”, clearly resembling the experience of serendipity.

### 5.5.1 Context factors and interfaces enabling serendipity

Moving on to the contribution concerning serendipity, in the user studies (Articles II, IV) context factors often drove the experience. However, the relation of context factors to the UI and concept level design choices is

a complex one. This makes it hard to separate the UX levels (Table 3) from each other for determining which one is the most important in enabling serendipitous experiences with music. For example, a certain UI solution may drive the whole concept of a service, as in the case of OUTmedia, where the concept was built around a context-sensitive mobile AR interface.

LifeTrak app's Contextual Equalizer (see Article V) is a rare example of an unconventional and multifunctional UI for music discovery. It functions as a combined refinement, user feedback as well as transparency and explanations aid. Furthermore, it gives user-controlled means to acquire potentially serendipitous music recommendations through a more informative visualization than a mere list. Contextual Equalizer and OUTmedia combine a rich set of dimensions from different levels of contextual music UX (Table 3). For example, OUTmedia utilizes all context factors except activity while Contextual Equalizer applies all except identity.

The OUTmedia prototype had context-sensitivity as its “positive restrictions” (Article IV) and as an innate UI feature, which also directed the concept design. It offered a variety of serendipitous encounters with music, user annotations and places through its AR interface and AR objects. Some of our users felt that context-sensitivity gave greater chances for serendipitous discoveries than the usual way of browsing online content anywhere and anytime. The popularity of features and media content varied broadly among the participants, showing that *exploration* was a prominent aspect of serendipity. The service concept supported not only serendipity but pseudo-serendipity (re-discovery) as well.

The other location-related themes *right here, right now* and *experiencing location through time* allowed serendipitous discoveries in the same vein as location-sensitivity. They enabled discoveries through the innate feature of the AR interface, allowing users to scan their surroundings in that particular place and at that particular moment in time, stressing the “live feel” characteristic rarely supported in earlier music recommenders (for an example from other content domain, Sofanatics was a service for following live sports events with a social media connection). The OUTmedia user study demonstrates the main design goals, proving that the prototype supported serendipitous discoveries through music, places and user annotations and overall engaged the users in music appreciation.

In the Sounds of Helsinki prototype, the context factors of time and location were applied for supporting serendipitous discoveries of music events during an urban festival. The Sounds of Helsinki field study (Article II)

demonstrates that suitably designed contextual (time and location-aware) recommendations can lead to serendipitous discoveries of music and events. The user data from the overall satisfaction survey shows that users were satisfied with the service concept and its recommendations for determining which events to attend. Users felt that Sounds of Helsinki was successful in adding a new urban layer in the participants' lives and intensifying the experience of living in the city's stream of events.

For example, minimizing the user effort with recommendations pushed to the user about an event that was about to begin nearby led to positive surprises. We aimed at offering users a simple and elegant way of receiving recommendations unprepared and while on the move. Furthermore, users did not need to train the recommender.

The UI level theme *multifunctionality* resonates well with serendipity. As pointed out in Section 5.3 and Article V, well-designed UI features can successfully serve several purposes. The OUTMedia AR interface is multifunctional in the same vein as Lifttrak's Context Equalizer (as reviewed in Article V) in that it functions as a combined feature for refinement as well as transparency and explanations. Through these dimensions, it offers user control for rapidly acquiring a new set of recommendations and thus potentially serendipitous encounters not only with music but places and other media as well. OUTMedia AR UI fuses together all the main themes presented in this chapter.

Summing up, there are many ways for promoting serendipity, therefore, the roles of context factors, various media types, and diverse UI features should all be considered carefully in designing for serendipitous experiences. Expert evaluations and design decisions can promote serendipity but in the end, it is a question of the user's preferences, personal history and cultural knowledge that cannot be easily designed in a system. In Article III, I envisioned a system that would support musical serendipity and affect urban culture by providing virtual and mediated layers upon the urban reality. By the user studies of two prototypes, I have shown that with context-aware music services, people can be offered new kinds of – often serendipitous – urban experiences.



## 5.6 Design implications

The following design implications are based on the key findings presented in the previous sections of this chapter.

### 1. Supporting open meaning-making

Better UX can be enabled by leaving a certain amount of openness and adaptability to the systems in order to support unexpected activities and open meaning-making. We encourage designers to provide features that support associative interplay of different media types (user-created vs. curated; music, text, visuals and combinations of them), social media and context factors.

Providing users features that support self-expression and open and associative personal meaning-making processes may lead to a better UX as has been proven by several popular social media services.

### 2. Visual and interactive explanations

As a design implication, we encourage designers to experiment with alternatives to textual explanations: visual and interactive UI elements that communicate the system logic or explain why a recommendation was made.

Visual and interactive explanations may give the user lots of information at one quick look whereas offering the same information by text requires much greater effort. This strategy works specifically when there are a great number of items to be shown or interact with.

### 3. Positive restrictions

We suggest designers experiment with physical and other “positive restrictions” in their designs. For example, with location-sensitivity as a positive restriction, allowing the content to be available only when the user is at or nearby a certain location.

The field studies (Articles II, IV) showed that many users appreciated that the content was not available online from anywhere and anytime, but only by actually going to the place where the music or other content was attached. However, careful design decisions are needed since if there is no

real added value of giving access to the content only on location, the positive restriction becomes only a restriction.

#### **4. Supporting serendipity**

There are several ways for promoting serendipity. We encourage designers to explore the following strategies:

Allow for an easy discovery of unexpected and unfamiliar content and people. For example, including social media features, together with context factors may help in supporting serendipitous discoveries.

Combining music with an activity, a location, certain time or an identity (a familiar or unknown user of a system) can effectively promote serendipitous discoveries.

As a general serendipity-related implication, we suggest designers experiment on every level of contextual music UX: with UI features, interfaces, context factors and service concept choices that allow users to encounter content, people and places in unconventional and potentially surprising ways.

Supporting serendipity means not only enabling better UX, but it has the potential to support cultural diversity as well (given that services supporting serendipity have large enough user bases). In this thesis, promoting cultural diversity is seen valuable as such (see 1.1).

#### **5. Minimizing the user effort**

When the use case allows, aim for

- short learning time,
- give the recommendations proactively,
- without preference elicitation,
- offer recommendations in an ad hoc fashion, targeted right to the moment, and
- use implicit context factor acquisition when feasible.

Minimizing user effort is based on one of the general usability guidelines: users must achieve their goals with minimum time and effort.

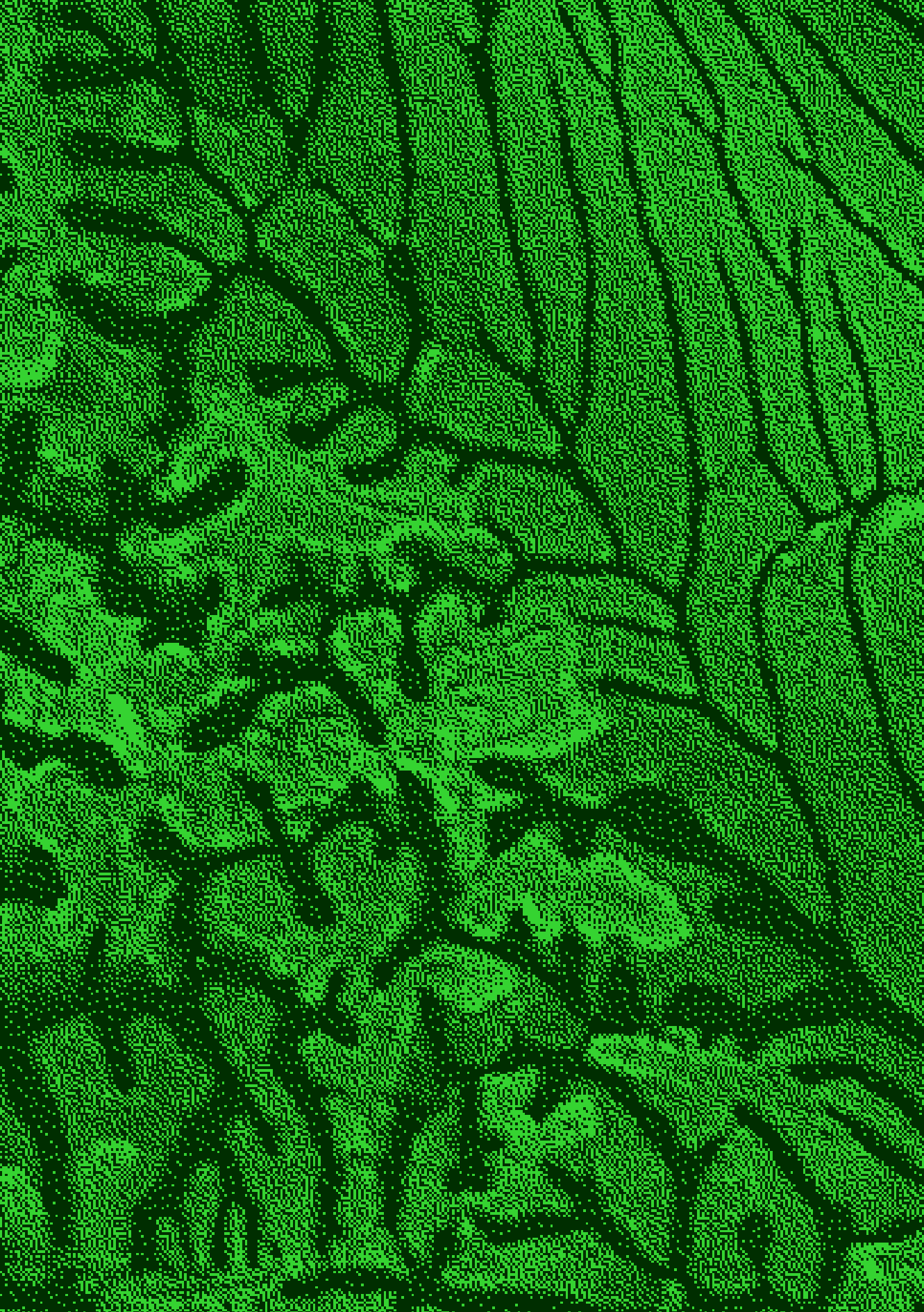
## **6. Filtering features**

We suggest designers experiment with advanced search and filter features when applying AR interfaces. Beyond location, the most meaningful filters would be by adopting sliders or dials for filtering by media type, users, popularity or by context factors time or identity.

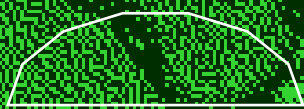
Filtering would be necessary for commercial systems with AR interfaces since the AR view becomes unavoidably crowded over time and therefore hard to use.

### **5.7 Summary**

The findings, themes and design implications presented above aim at enabling people to experience personal reality and urban environments in rewarding ways through UI features, music content, context factors and concept level choices. However, great care must be taken when applying the above suggestions since they may conflict with each other when applied to the same system. For example, minimizing user effort may conflict with open meaning-making or adding filtering features. In the next chapter, I discuss the challenges and limitations of this work and conclude by envisioning potential future research directions.



## 6 DISCUSSION



In this chapter, I recapitulate the main contribution of the thesis and reflect on the applicability of the results before addressing some of the challenges, issues and limitations encountered during the process. I conclude by taking a look at the future of contextual music recommendation and discovery and other future directions in the domain of contextual user experiences.

Today, almost all music that has been recorded is already available in some form online. The problem for the consumers is finding the most interesting music from the catalogs of millions of tracks. When I started this work, I set out to investigate the ways in which context factors could help in discovering interesting content from the vast libraries of online music.

In the articles, I, together with my co-authors, presented concepts and prototypes showcasing the potential uses of context factors and analyzed interactions and context factors in commercial services and research prototypes. The contribution presented in Chapter 5 demonstrates that involving context factors in music recommendation and discovery can lead to rewarding user experiences and serendipitous discoveries of music, specifically in the urban environments of the field studies. As discussed in Articles II and IV, users felt that the discovery of music and events improved the quality of the everyday life, showing the potential for similar commercial services.

On a more abstract level, my work has an ethical undercurrent: promoting cultural diversity as well as co-creation of urban environments with music-related applications. It has aimed to empower people by offering means to mold their environments by creating, experiencing and sharing virtual, augmented layers of music. As an inspiration, I applied notions such as strategy versus tactics (de Certeau, Giard, & Mayol, 1998) and contextual music as invisible graffiti (Article III) to create service concepts and concrete prototypes (Sounds of Helsinki, OUTMedia) that could support at least some of the hundreds of millions of mobile device users to enjoy new kinds of contextual experiences.

I believe that the findings, themes and design implications have the potential to be applied in commercial services. I hope that my work helps in

accumulating new knowledge and opening new directions in the domain of social media since there have been relatively few studies conducted on music and social media services from the contextual point of view. Furthermore, various contextual services (e.g. mobile shopping, advertising, travel and lifestyle applications) that sense people's activity or location may benefit from my work. The design implications I presented in Section 5.6 can help in designing commercial media recommendation services that are expanded by social media features or contextual recommendations embedded in social media.

In the light of the field studies, it seems that the current work, as well as the reviewed similar kinds of contextual media and events discovery concepts and their interactions, would be feasible for various services designed for urban events, from sports and culture events to travel applications. I expect these kinds of commercial services and applications with the interconnectedness of data from contextual services and social media sources to become everyday technology soon. In short, I have shown that in urban music experiences, context really matters. Having said that, there were also challenges and limitations, which I will address next.

## 6.1 Challenges and limitations

### 6.1.1 Limitations concerning the technological definition of context

The concept of context is anything but straightforward to address thoroughly. Dey and Abowd's (1999) definition is refined from numerous earlier definitions, and I chose it for the main notion of context mainly for pragmatic reasons. By defining context as measurable and reducible to four main context categories of location, time, activity and identity, the concept becomes clear and unequivocal so that it can be used in pragmatic design work. A clear definition helped in categorizing different ways the context factors could be involved in the concepts and service prototypes. However, this definition of context relies heavily on technology.

Dourish (2004) criticizes the technological (or Positivist, as he calls it) view on context for simplifying context into mathematical and objective models. He sees that context is essentially a subjective construct, resulting in an ever-changing interpretation of what someone experiences in a situation.

Dourish's view on context owes much to Phenomenological philosophy (for a thorough discussion, see Dourish, 2001).

In Chapter 2, I also reviewed Krippendorff's view on context that derives from his "product semantics" (Krippendorff, 2006; 2007). Dourish's and Krippendorff's views were involved in the design and research process as well, as a complementary, inspirational manner as well as for explaining the use of technologies and the meanings people construct of them, as discussed in Section 4.3.

As my results show, although I applied the technological definition of context as a group of measurable information types, users made the context-aware recommendations their own by interpreting, negotiating and actively constructing their own meanings out of them. Therefore, although I mainly used the technological definition, it did not turn out to negatively affect the design output since contextual music user experience is unavoidably subjective and negotiated in use, as highlighted by Dourish and Krippendorff.

The results of my thesis indicate that all of the three views of context are useful when applied in the different phases of the design and research process. For example, they might be applied for narrowing down the full spectrum of contextual possibilities to the feasible options of an application while sometimes only as an inspiration for design ideation. The latter function of the use of different views on context highlights the contrasting goals of design and science: in design, the primary purpose is not to seek the truth, but make the world better by designing useful, aesthetic and ethically sustainable products and services that offer rewarding user experiences.

Although its limitations, the technological definition proves itself useful for the design process in its clarity and unequivocalness. Both Krippendorff's and Dourish's definitions of context unavoidably realize themselves in the actual use of a service or product. In design activity, any concept can be used as an inspiration, while in design *research* as a scientific endeavor, clear definitions of the concepts used must be provided.

### 6.1.2 Serendipity is not always the desired outcome

The second challenge or limitation concerns the central concept of my work, serendipity. In recommendation research, it is conceived as a combination of novelty and relevance, a positive experience often including an element of surprise in it. However, as pointed out in Section 5.5, there are



many situations where serendipity is not the welcome outcome of a musical experience. For example, a reuniting group of friends may want to listen to the familiar music that bound them together years ago, not unfamiliar and surprising music. Indeed, supporting pseudo-serendipity (as discussed in 3.5.1) could be a very lucrative research direction for the nostalgic value it arises in music listeners.

As discussed in Chapter 3, there is also a trade-off between serendipity and relevance (or novelty and familiarity). I see that the essence of it is in balancing the unfamiliarity with the positivity: new music must be relevant, i.e. the listener must like it and therefore it must, to some extent, comply with her music preferences. However, to be serendipitous, recommended music has to be unfamiliar and therefore it may clash with the user's music preferences. The trade-off between relevance and novelty is discussed in detail for example by Celma (2010).

Discovery and familiarity must be balanced and users must have control over the ratio thereof, for example for the situations when novel content is desired to be complemented with familiar music. Yet, serendipity cannot be achieved without taking into account the user profile, and approaches to user preferences and profiling vary greatly in the existing systems. In many systems, personalization through user preferences is used to filter the available content, offering those items that are novel and relevant.

Ideally, the user should first be offered some familiar items in order to build the confidence and trust towards the recommender. Explanations of why certain music was recommended increase confidence and transparency of unfamiliar music. The challenge is to find the right balance between familiarity, novelty and relevance for each person. By following this strategy, recommenders can take advantage of the long tail. Over time, the user interaction with the system changes the balance between novelty, familiarity and relevance so the number of familiar recommendations can be reduced. (Celma, 2010).

Similar to broadcast radio that attracts its listeners by recurrent familiar content, carefully mixing it with new tunes, contextual music recommenders must achieve that as well and not only try to build on the discovery aspect.

From the point of view of the underlying ethical leitmotif of this thesis, cultural diversity, I see promoting serendipity paramount at a societal level. For example, in the context of modern playlist radio, working in a constant compromise with the large music business actors and even payola practice, the more radio channels and music services there are that direct cultural

consumption towards the long tail, the more diversity the society can foster. In fact, some radio stations do not use playlists and apply this strategy as a marketing message for reaching certain kinds of audiences and highlighting their independence from the big music industry players. Furthermore, streaming services can drive the consumption towards long tail by including advanced recommendation features and context factors. For example, Spotify introduces regularly new personalization features, such as *Discover weekly* feature, which is based on the user's listening history.

Serendipity can be promoted in many ways. I have applied context factors, UI features and service concepts for promoting it. In the background, notions such as psychogeography, graffiti, *dérive* and flaneurism have provided the needed inspiration for the concept design. Many of these concepts were born as radical societal notions and practices; I have adapted them to the area of music-related urban experiences.

### 6.1.3 Context → long tail → serendipity → cultural diversity

As presented in Section 1.1, context-aware recommendations would ideally lead to serendipitous discoveries by offering unfamiliar music from the long tail, and ultimately, if there were millions of users using context-aware music services, cultural diversity would be maintained or even increased. However, maybe the most severe limitation of this work concerns the above chain of argumentation. In the scope of this thesis, the whole chain could not be proven. Specifically, the step from serendipity to cultural diversity remains an ideal, but an important one, an ideal that can be used to guide the design process. Furthermore, it could be argued that adding context information to music recommendation does not necessarily lead to serendipitous (unfamiliar and relevant) recommendations. This may indeed vary from case to case. In some cases, if not designed well (e.g. connecting context factors to the user's personal situation in some meaningful way) it may lead to no better recommendations than randomly picked music. Sometimes context information increases relevance by producing recommendations that suit the situation. Sometimes context drives recommendations towards unfamiliar music, but that can depend for instance on the diversity of the user base that is used to produce the recommendations. In the case of my two field studies, most of the users experienced serendipity as well as enjoyed using the prototypes. Although the results may not be generalized to all context-aware

music recommendation cases, the design implications may prove to be useful for the designers and researchers of future systems.

#### 6.1.4 Social issues with augmented reality

Finally, as AR is not an everyday technology yet, privacy issues arise when it is used in public spaces. Using a mobile phone with an AR interface for browsing the user's surrounding can easily be misunderstood as the user recording video of the surroundings *and* the people within it. There are still no social norms for showing people in a public space that they are not being photographed or videoed, but the user is exploring one's surroundings through a smartphone AR interface. In future research, socio-technical solutions to solve AR-related privacy issues must be developed. An elegant communicative indicator might solve the problem.

Eyeglasses with AR (e.g. Google Glass, GlassUp) may prove even more problematic since those being potentially recorded or face-recognized do not know they are being recorded or observed through an augmented information layer. It is likely that mobile AR will eventually become diffused in the everyday life, but in order to accelerate this development, socio-technical solutions should be developed. Maybe Pokémon GO and the next successful mobile AR applications are enough to solve the issue by making the technology familiar by its presence in the everyday life.

The social issues with mobile AR resemble two earlier techno-social cases that were solved by the diffusion of the technologies in question and people thus becoming accustomed to them. First, nowadays, people are quite adjusted to encounter people who, at first glance, seem to be talking to themselves. In the late 1990s, when hands-free mobile phone gadgets were a novelty, talking to yourself while walking on the street might have gathered looks but rarely was thought of as a threat to someone's privacy.

A second case from the last decade highlights the fact that the solution for a new personal media technology use may be social or technological or a mix of both. American phone users used to have a strong preference for flip cover phones. Flipping the cover open was used for social signaling, showing that the phone user was partly exiting the current social context by creating a virtual social context, a phone conversation. The technological supremacy and social value of iPhone and the subsequent touch-screen phones caused a disruption (Bower & Christensen, 1995) and removed the desire for phones with a cover. However, the practice has survived with those who prefer

wallet-like phone covers that can be flipped over when starting to use the phone.

## 6.2 Future research directions

The purpose of this thesis was to investigate novel concepts and ways for interacting with recorded music by involving context factors. I have provided some suggestions, but at the same time, new paths open up. In the following, I present three potential future research directions.

*Expanding the spectrum of context factors* involved in recommendations would be a logical way to pursue the research further. Maybe the most promising directions open up in the areas of social and affective computing, specifically in *social context, mood and emotions*. They have already been involved in music recommendation, but so far mainly relying on explicit user-input or social media data mining, not direct sensing. As soon as sensing of social context, mood and emotions can be implemented in ubiquitous personal devices in a feasible way, prototypes can be introduced for contextual and social media services. One direction could be recommending music based on the surrounding people's moods, maybe as an aggregate, resulting in a "social mood" driving the recommendations either to overcome the surrounding social mood or intensifying it with music or other media. I see that all three views on context presented in Chapter 2 should be applied in mapping out the design space for novel and experimental contextual UX, as I noted in 4.4.

*Music-enhanced well-being* is another lucrative area for applying context factors such as biosignals, mood and social factors. There are numerous applications for exercising, but for example sleep and stress management, while widely studied in music psychology (North & Hargreaves 1996; Levitin 2007), is still relatively unexplored regarding interactive applications. The interfaces of these systems could be radically different from the usual radio or playlist metaphors, adopting for example, gestural, movement and audio-based controlling. Beyond the obvious biodata such as heart rate, skin conductivity and blood pressure, uncommon and experimental context factors could be applied in the field of well-being and music. Potential context factors include motion data and posture; force and touch; optical data (environmental or object shapes, lighting conditions); audio data (background noise, speech), and proximity data (distance, nearby objects) (see

for example Boström, 2008; Kaminskas et al., 2015; Kaminskas & Ricci, 2012; Mayrhofer, 2004; Schmidt, 2002).

Third research direction concerns the colliding of the physical and digital realms that is already happening through *augmenting spaces and places* with sensing technologies, data analytics and novel interfaces. Densely populated urban areas are the main sites for this development since they offer lots of data points and content generated by the flows of people moving around. This connected world will be the frame for the everyday urban life in the next decades, offering new opportunities for service businesses as well as personal and cultural expression. Current interfaces for augmented environments rely mainly on two and three-dimensional maps and information presented over a camera view, but in the near future, more natural interfaces such as audio-only, gestural and other movement-based solutions may become more common. Research directions open up in studying technologies that allow not only receiving augmented experiences but also creating, remixing and controlling them by the users. Augmented spaces and places can be conceived as numerous layers of which desired ones can be switched on and off upon request.

On the concrete level, the most interesting next steps in order to explore further my original research question “How to design serendipitous, rewarding and enjoyable concepts and interactions for contextual music recommendation and discovery?” boil down to experimenting with prototypes that would suggest music to various situations by including not only time and location but applying also social context and biodata, together with smart balancing between familiarity and serendipity. The directions presented above have touchpoints with the currently much-debated Internet of Things. This development may change the internet as we know it by vanishing it in the background, so that it will resemble the other pieces of infrastructure, working somewhere in the background. In the next section, I illustrate the ways the aforementioned developments could support and enrich the everyday life as a Spotify or Pandora of the near future.

### 6.3 Conclusions

In the opening paragraphs of this work, I stated the fundamental themes for my research as fostering cultural diversity through designing contextual, serendipitous music recommendation and discovery (see 1.1 for

how this would ideally happen). During my work, I have created concepts and prototypes that allow people to find new interesting music differing from the content that populates the playlist radio and other mainstream media channels.

My work contributes to the wide, multidisciplinary field of research that may lead in the near future to personal, yet socially connected systems that sense and analyze data and suggest content and ways of behavior. This development started by the early visions of the digital technologies in the late 1960s and accelerated substantially by the wide diffusion of mobile personal devices in the 1990s (Negroponte, 1995; Wardrip-Fruin & Montfort, 2003; Weiser, 1991). In the coming decades, technologies such as personalized big data access and analysis, wearables, implants, augmented and virtual reality will be in the center of the socio-technological development.

For almost two decades, since the first era of digital music, that is, the download distribution model (Liikkanen & Åman, 2015), the music industry has been in a state of fermentation. How could contextual music recommendation and discovery help the artists, the industry, and most importantly, music lovers?

Today, the single biggest hurdle for ubiquitous and universal music use is the lack of unified copyright agreements across different services, operating systems and geographic areas. Universal access to all music is a prerequisite for advanced contextual music services and it was one of the main premises for the concepts and prototypes presented in the Articles II, III and IV.

In the near future, context information, combined with personalization and discovery features can provide a win-win situation for all stakeholders in the music domain. Consumers would be delighted to discover new, interesting artists with the help of recommendation algorithms, context information and other data deduced from their past behaviors, social context or the listening habits of their friends.

Artists would benefit from long tail recommendations by increasing the number of streams, but also by turning some of the casual listeners to committed fans, as the reach of recommendations would cover their full catalog with rarities and forgotten pearls.

Music service providers will be able to keep existing users active and lure new ones by gathering more data (of plays, thumbs-up, social networks, etc.), analyzing it and using this knowledge to introduce new features. Today's music data and computing technology already allow multiple ways in which music discovery can be brought to the people. Diverse user groups'

diverse needs and desires must be catered for, and personalization, together with context and data analysis is the key.

Social media with media recommendation features and media content services with social media connection are examples of interconnected personal and social data flows that can be used for personalization and recommendation. The future might be in the hybrid systems combining word-of-mouth and electronic word-of-mouth (social media), together with machine-made recommendations. Those "all-inclusive" systems would apply a wide variety of data input from sources that include not only media-related information, but also any data produced by the user interacting with her applications. These may include well-being apps such as stress management or sleep aids, other self-monitoring apps, urban augmentation, together with all social channels, combined with a simple switch for a bypass mode and strict privacy.

In the concepts and prototypes presented in this work, I have tried to support music recommendation and discovery from the end of the long tail, for the sake of serendipity and cultural diversity. One of the main motivations in developing new applications and service prototypes lies in their lucrativeness. It is common that in research plans written for funding, promises about the vast potential of commercial applications of the research output are made. Having said that, I do not see promoting cultural diversity in opposition to successful business. When a company is selling content from the tail end, it is a question of selling *more of less*, as Anderson (2006) put it, and when carefully designed contextual music recommendations drive the sales up, ethics and business promote each other in a reciprocal manner.

The democratizing potential of digital media is illustrated by the applications presented in this thesis. They aim to give every one of us the possibility to weave novel fabrics of and augment the surrounding reality and to eradicate the limitations of space and time with context-aware music discovery. I hope that my work will help designers and researchers to fully explore the potential of contextual digital media for enriching people's life.

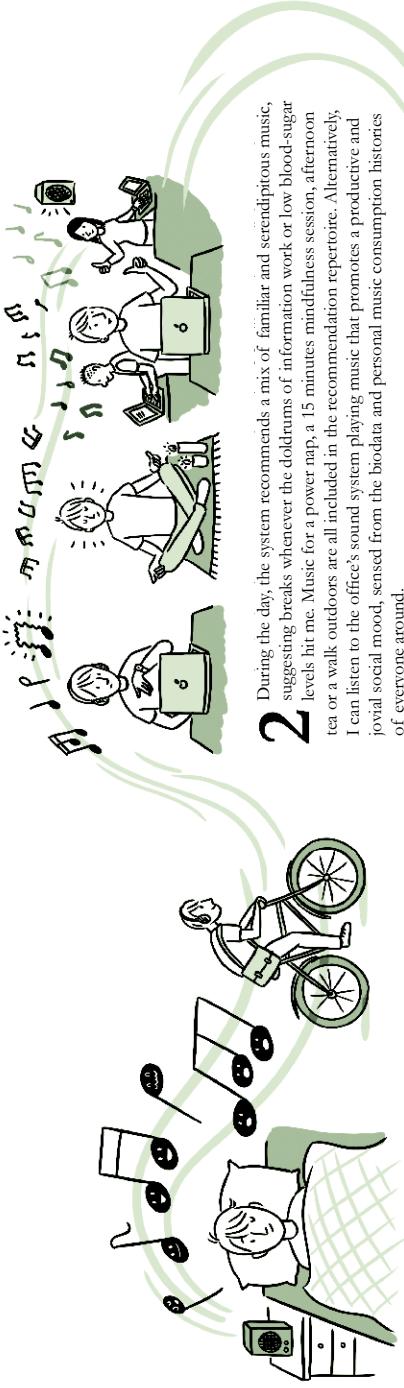
#### 6.4 **Scenario: personal media with full spectrum of context**

The following scenario builds on the themes discussed in the previous chapters and is enabled by technologies such as recommendation algorithms,

sensors tracking different types of contextual information, augmented reality, advanced data analysis, interactive information visualization and speech and gestural user interfaces.

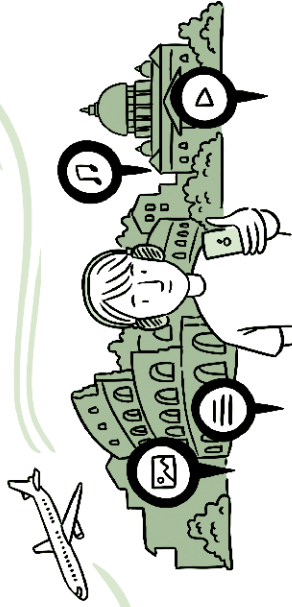
**Figure 16** A scenario of a future personal context-aware recommendation system (illustration by Salla Vasenius).





**1** Waking up, my media system plays music that helps to cut through the morning REM cycle and prepare me to the day's schedule by playing a right mix of music from moods spanning from energetic to relaxing and happy to angry. The music for waking up and commuting is based on my sleep patterns and previous performance levels of the days resembling the expected agenda and situations of that day, taking account also social context such as whom I will be working with.

**2** During the day, the system recommends a mix of familiar and serendipitous music, suggesting breaks whenever the doldrums of information work or low blood-sugar levels hit me. Music for a power nap, a 15 minutes mindfulness session, afternoon tea or a walk outdoors are all included in the recommendation repertoire. Alternatively, I can listen to the office's sound system playing music that promotes a productive and jovial social mood, sensed from the biodata and personal music consumption histories of everyone around.



**3** After taking a night flight from Montreal to Rome, I explore the myriad cultural layers of the eternal city, created by the curators of Vatican museums, the city's tourist authorities, the populace of Rome and the millions of tourists that have visited the city and created sharable layers of urban experiences through context-aware text, video, photos and music.



**4** Finally, in the evening, in another hotel room and with another jet lag, my personal media service helps me to wind down and prepare for a good night's sleep by playing soothing music together with a light projections that have previously worked in similar situations, changing my brain activity levels towards rest.

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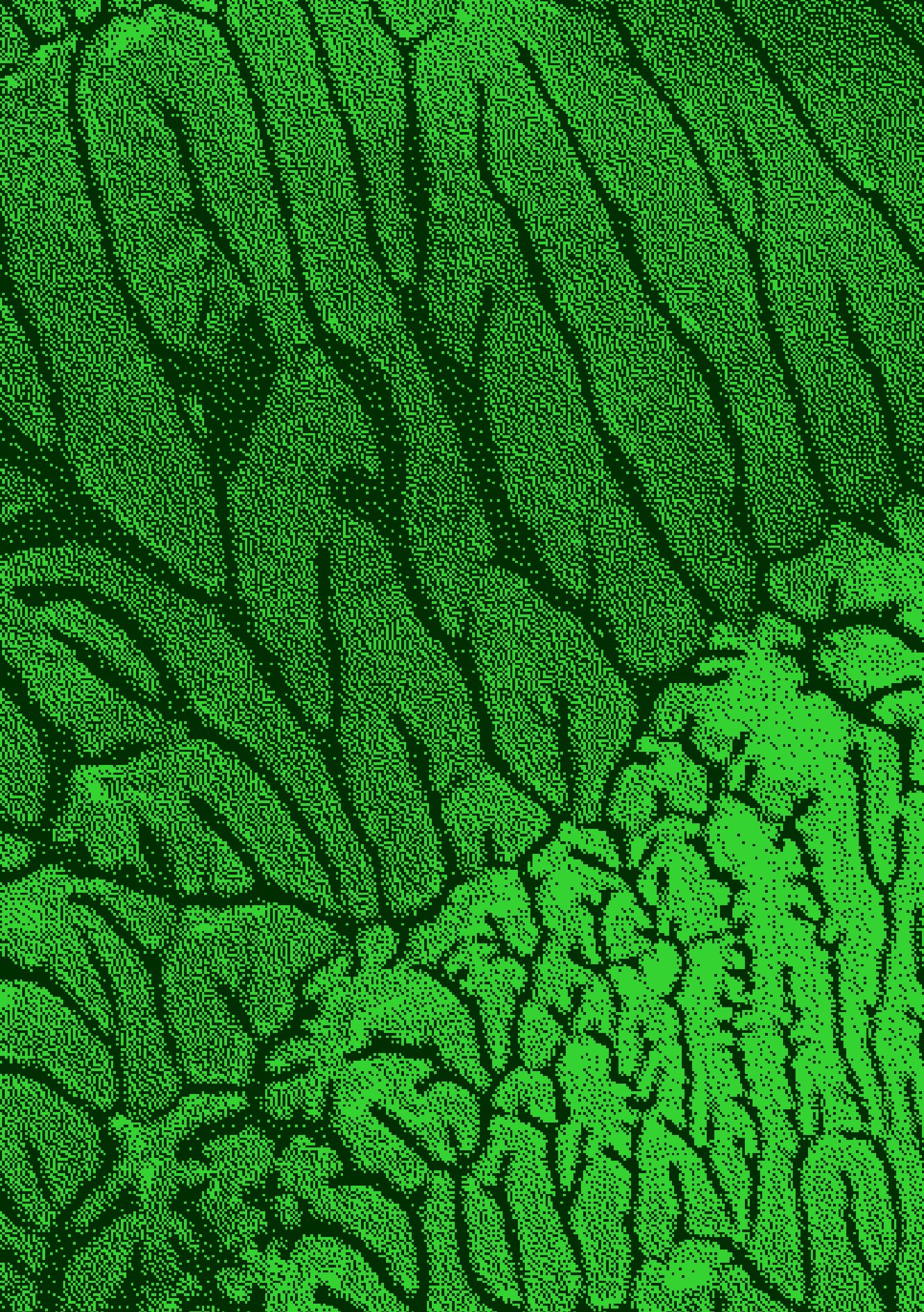


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**Article 1**  
A SURVEY OF MUSIC  
RECOMMENDATION AIDS

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# A Survey of Music Recommendation Aids

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## ABSTRACT

This paper provides a review of explanations, visualizations and interactive elements of user interfaces (UI) in music recommendation systems. We call these UI features “recommendation aids”. Explanations are elements of the interface that inform the user why a certain recommendation was made. We highlight six possible goals for explanations, resulting in overall satisfaction towards the system. We found that the most of the existing music recommenders of popular systems provide no explanations, or very limited ones. Since explanations are not independent of other UI elements in recommendation process, we consider how the other elements can be used to achieve the same goals. To this end, we evaluated several existing music recommenders. We wanted to discover which of the six goals (transparency, scrutability, effectiveness, persuasiveness, efficiency and trust) the different UI elements promote in the existing music recommenders, and how they could be measured in order to create a simple framework for evaluating recommender UIs. By using this framework designers of recommendation systems could promote users’ trust and overall satisfaction towards a recommender system thereby improving the user experience with the system.

## Categories and Subject Descriptors

H5.m. Information interfaces and presentation: Miscellaneous.  
H.5.5 Sound and Music Computing.

## Author Keywords

Recommendation systems, music recommendation, explanations, user experience, UI design.

## 1. INTRODUCTION

Recommender systems are a specific type of information filtering technique that aims at presenting items (music, news, other users, etc.) that user the might be interested in. To do this, information about the user is compared to reference characteristics, e.g. information on the other users of the system (collaborative filtering) or content features, such as genre in the case of books or music (content-based filtering). In its most common formulation, the recommendation task is reduced to the problem of estimating relevance of the items that a user has not encountered yet, and then presenting the items that have the highest estimated ratings [6]. The importance of recommender systems lies in their potential to help users to more effectively identify items of interest from a potentially overwhelming set of choices [7]. The importance of these mechanisms has become evident as commercial services over the Internet have extended their catalogue to dimensions unexplorable to a single user. However, the overwhelming numbers of content create a

constant competition and can reduce the usefulness of recommendations unless they can persuade the user to try the suggested content. Explanations and other recommendation aiding UI features are examined in this paper as a way to increase the satisfaction towards recommenders among users.

The first interactive systems to have explanations were expert systems, including legal and medical databases [4]. Their present successors are commercial recommendation systems commonly found embedded in various entertainment systems such as iTunes [9] or Last.fm [12]. Explanations can be described as textual information telling e.g. why and how a recommendation was produced to the user. Earlier research shows that even rudimentary explanations build more trust towards the systems than the so-called “black box” recommenders [13]. Explanations also provide system developers a graceful way for handling errors that recommender algorithms sometimes produce [6].

The majority of previous recommendation system research has been focused on the statistical accuracy of the algorithms driving the systems, with little emphasis on interface issues and the user experiences [13]. However, it has been noted lately that when the new algorithms are compared to the older ones, both tuned to the optimum, they all produce nearly similar results. Researchers have speculated that we may have reached a level where human variability prevents the systems from getting much more accurate [7]. This mirrors the human factor: it has been shown that users provide inconsistent ratings when asked to rate the same item several times [14]. Thereby an algorithm cannot be more accurate than the variance in the user’s ratings for the same item.

An important aspect for the assessment of recommendation systems is to evaluate them subjectively, e.g. how well they can communicate their reasoning to users. That’s why user interface elements such as explanations, interactive elements and visualizations are increasingly important in improving user experience. In the past years subjectively perceived aspects of recommendations systems have accordingly gained ground in their evaluation.

In this paper we want to illustrate the possibilities of user-evaluation of recommendation supporting features in recommendation systems. We do this by performing a review on several publicly available music recommenders. Music is today one of the most ubiquitous commodities and the availability of digital music is constantly growing. Massive online music libraries with millions of tracks are easily available in the Internet. However, finding new and relevant music from those vast collections of music becomes similarly increasingly difficult. One approach to tackle the problem of finding new, relevant music is developing better (reliable and trustworthy) recommendation systems. Music recommenders are also easy to access and music has reasonably short process in determining the quality of recommendation results.

## 2. GOALS FOR RECOMMENDATION AIDS

Tintarev and Masthoff [16] present a taxonomy for evaluating goals for explanations. Those are shown slightly modified in the Table 1 below. We argue that satisfaction towards a recommendation system is an aggregate of the six other dimensions, more a goal of itself than the other dimensions. In addition, we noticed that the dimensions are not so straightforward as Tintarev and Masthoff present them. Some of them cannot be evaluated using objective measures, and therefore framework for evaluation recommendation aids must be drawn from user research. In the following we describe each dimension and give examples of how they could be evaluated and measured.

**Table 1. Dimensions for recommendation explanations.**

Goal	Definition
Transparency	Explain how the system works
Scrutability	Allow users to tell the system it is wrong
Effectiveness	Help users make good decisions
Persuasiveness	Convince users to try or buy
Efficiency	Help users make decisions faster
Trust	Increase users' confidence in the system

Resulting in →

Satisfaction (increasing the ease of use or enjoyment towards the system)
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1. An explanation may tell users how or why a recommendation was made, allowing them to see behind the UI and thus making recommendation *transparent*. Transparency is also a standard usability principle, formulated as a heuristic of 'Visibility of System Status' [13]. Transparency can be measured objectively, using binary scale (yes/no), e.g. if a UI provides some kind of explanation how a recommendation was made transparency gets a vote. However, evaluating transparency subjectively may involve users to be asked if they understand how the recommendation was made using e.g. Likert scale.

2. *Scrutability* means that users are allowed to provide feedback for the system about the recommendations. Scrutability is related to the established usability principle of 'User Control' [13]. Scrutability can be measured objectively by finding out if there is a way to tell the system it is wrong. To evaluate scrutability subjectively, users may be given a task to find a way to tell how to stop receiving e.g. recommendations of Elvis songs. If users feel they can control the recommendations by changing their profile, the UI has the possibility to scrutinize.

3. *Effectiveness* of an explanation help users make better decisions. Effectiveness is highly dependent on the accuracy of the recommendation algorithm. An effective explanation would help the user evaluate the quality of suggested items according to their own preferences [16]. This would increase the likelihood that the user discards irrelevant options while helping them to recognize useful ones. Unlike travel or film recommenders, in the case of music recommenders the process of deciding the goodness of a recommendation is done quite quickly.

4. *Persuasiveness*. Explanations may convince users to try or buy recommended items. However, persuasion may result in an adverse reaction towards the system, if users continuously decide to choose bad recommendations. Persuasion could be measured according to how much the user actually tries or buys

items compared to the same user in a system without an explanation facility [16] and what kind of persuasion techniques are utilized. Persuasion could also be measured by applying click-through rates used in measuring online ads.

5. *Efficient* explanations help users to decide faster which recommendation items are best for their current situation. Efficiency can be improved by allowing the user to understand the relation between recommended options [12]. A simple way to evaluate efficiency is to give users tasks and measure how long it takes to find e.g. an artist that is novel and pleasing to the user.

6. Increasing users' confidence in the system results in *trust* towards a recommender. Trust is in the core of any kind of recommendation process, and it is perhaps the most important single factor leading to better user satisfaction and user experience with the interactive system. A study of users' trust (defined as perceived confidence in a recommender system's competence) suggests that users intend to return to recommender systems, which they find trustworthy [2]. The interface design of a recommender affects its credibility and earlier research has shown that in user evaluation of web page credibility the largest proportion of users' comments referred to the UI design issues [5]. Trust needs to be measured using subjective scales over multiple tasks or questions about the recommendation aiding features of a recommender UI.

The ease of use or enjoyment results finally in more *satisfaction* towards a system. Descriptions of recommended items have been found to be positively correlated with both the perceived usefulness and ease of use of the recommender system [6], enhancing users' overall satisfaction. Even though we see satisfaction as an aggregate of the dimensions presented above, satisfaction with the process could be measured e.g. by conducting a user walk-through for a task such as finding a satisfactory item.

## 3. RELATED EMPIRICAL RESEARCH

It is widely agreed that expert systems that act as decision-support systems need to provide explanations and justifications for their advice [13]. However, there is no clear consensus on how explanations should be designed in conjunction with other UI elements or evaluated by users. Studies with search engines show the importance of explanations. Koenmann & Belkin [11] found that greater interactivity for feedback on recommendations helped search performance and satisfaction with the system. Johnson & Johnson [10] note that explanations play a crucial role in the interaction between users and interactive systems. According to their research, one purpose of explanations is to illustrate the relationship between cause and effect. In the context of recommender systems, understanding the relationship between the input to the system (ratings and choices made by user) and output (recommendations) allows the user to interact efficiently with the system. Sinha and Swearingen [15] studied the role of transparency in recommender systems. Their results show that users like and feel more confident about recommendations that they perceive transparent. Explanations allow users to meaningfully revise the input in order to improve recommendations, rather than making "shots in the dark."

Herlocker and Konstan [6] suggest that recommender systems have not been used in high-risk decision-making because of a lack of transparency. While users might take a chance on an opaque movie recommendation, they might be unwilling e.g. to commit to a vacation spot without understanding the reasoning

behind such a recommendation. Building an explanation facility into a recommender system can benefit the user in various ways. It removes the “black box” around the recommender system, providing transparency. Some of the other benefits include *justification*. If users understand the reasoning behind a recommendation, they may decide how much confidence to place in the suggestion. That results in greater *acceptance* or *satisfaction* of the recommender system as a decision aide, since its limits and strengths are more visible and its suggestions are justified.

#### 4. RECOMMENDATION AIDS IN EXISTING MUSIC RECOMMENDERS

We conducted an expert walkthrough of six publicly available music systems with recommendation functionalities in order to find out which of the six goals explanations, visualizations and interactive UI elements promote in the existing music recommenders, and how they can be measured in order to create a simple framework for evaluating recommenders. The walkthrough was conducted by authors listing the UI features capable of promoting the goals mentioned above. The reviewed systems include Pandora, Amazon, Last.fm, Audiobaba, Musicoverly and Spotify. We wanted to include the most popular online music services, and on the other hand, include a variety of different UIs. Each of the evaluated systems provides recommendations but not necessarily explanations. Systems without textual explanations were also included in order to find out what kind of goals or functions similar to verbal explanations other recommendation aids provide.

**Table 2. The occurrences of recommendation aids in a selection of music recommenders**

	Trans.	Scrt.	Effect.	Pers.	Effic.	Trust	
Amazon	1	2	2	3	1	3	12
Last.fm	-	2	2	1	2	2	9
Audiobaba	1	1	2	1	1	2	8
Musicoverly	2	2	2	2	2	1	11
Spotify	-	-	1	1	1	1	4
Pandora	2	2	3	3	2	3	15
	6	9	12	11	9	12	

If a recommender has a possibility to promote a goal with explanations, visualizations or interactive elements, it gets a vote in Table 2. For example, persuasiveness promoted through visualizations is potentially possible in all of the interfaces that have visualizations, even rudimentary ones, such as an album cover. A single user might be persuaded to try or buy by presenting a subjectively compelling album cover. From Table 2 we can see that Pandora, Amazon and Musicoverly have the greatest number of UI elements able to provide users support for sense-making of recommendations. Effectiveness, persuasiveness and trust are the most commonly promoted goals. In each recommender, each UI element has the potential to increase trust towards the systems, but for more accurate measurement, it remains to be evaluated by empirical user research, to which extent each element in certain recommender interface really promote trust. This applies to most of the six goals: without empirical data, it is almost impossible to decide, whether the potential for promoting effectiveness, persuasiveness and efficiency actually realizes. Only transparency and scrutability can be measured using objective binary scale of yes/no, but they can be evaluated also using subjective (Likert style) scales. We argue that by measuring these goals for UI elements together with a set of usability guidelines, it is possible to evaluate and design better user experiences for recommendation systems.

Some of the dimensions are easy to connect to certain UI elements. For instance, scrutability is usually designed as a combination of explanation and interactivity, whereas other, more general level dimensions depend strongly on subjective experience and are hard to connect with specific UI elements. For example, satisfaction or trust towards a system is usually combination of different experienced UI dimensions. Therefore the most common dimensions promoted in the evaluated systems were trust and satisfaction. Those, together with persuasiveness, are experienced very subjectively, which means that empirical user evaluation is needed for more reliable and comparable evaluations of those dimensions.

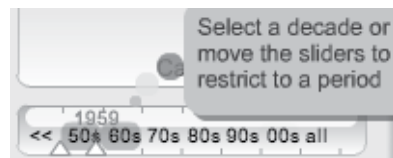
Obvious example of an explanation providing transparency is Amazon’s “Customers with Similar Searches Purchased...”, with up to ten albums’ list. Pandora tells a user: “This song was recommended to you because it has jazzy vocals, light rhythm and a horn section.” Transparency is very hard to achieve without textual, explicit explanations. Of the reviewed systems, only Musicoverly’s UI with several interactive elements, graphical visualization of the recommendations and the relations between them give users clear clues of why certain pieces of music were recommended, without providing explanations.

Last.fm offers users scrutability in many ways, e.g. with its music player (Figure 1). One of the system’s more sophisticated scrutinizing tactics is a social one. Last.fm allows users to turn off the registering (called scrobbling) of the listened music. The system’s users can perform identity work by turning scrobbling off, if they feel they do not want to communicate what they have listened to the other users. Amazon provides “Fix this recommendation” option for telling the system to remove recommended item from the users browsing history.



**Figure 1: Example of scrutable interactivity: Last.fm player’s love, ban, stop and skip buttons give users a tool to control their profiles and thereby affect recommendations.**

Users can be helped in efficiency and effectiveness, i.e. making better and faster decisions by offering appropriate controls with interactive elements. For instance, Musicoverly’s timeline slider is presented in Figure 2. It works in real time with the system’s graphical presentation of recommended items.



**Figure 2: Musicoverly’s timeline slider: interactivity promoting efficiency, scrutability, and effectiveness, resulting in more trust and satisfaction towards the system.**

#### 5. DISCUSSION AND CONCLUSIONS

We reviewed dimensions of explanations in six music recommendation systems and found out that most of the reviewed commercial music recommendation systems are “black boxes”, producing recommendations without any, or



very limited explanations. Most of the dimensions are poorly promoted by textual explanations, but can be promoted by other means, namely by visualizations and interactive elements, and further, by user-generated content and social facilities. From the expert walkthrough of the selected music recommendation systems we can draw a tentative conclusion that if UI elements can fulfill similar functions as explanations, there is necessarily no need for textual descriptions. By using non-verbal recommendation aids as “implicit” explanations and using them in recommendation system design, we can promote better user experience. This is the case especially when the user has enough cultural capital and therefore competence for “joining the dots” between recommended items without explicit explanations. On the other hand, if the recommender is used e.g. for learning about musical genre, textual explanations may be indispensable.

As an example of the dimensions that UI elements other than verbal explanations can promote is the overall satisfaction or trust towards the systems that can be achieved by conversational interaction such as in UI example presented in Figure 3, where users are given a chance for optional recommendations based on their situational desires and needs.

**Do you want?**

- Relevant tracks
- Novel tracks
- Serendipitous tracks
- A killer playlist

**Figure 3: A recommendation aid with optional inputs.**

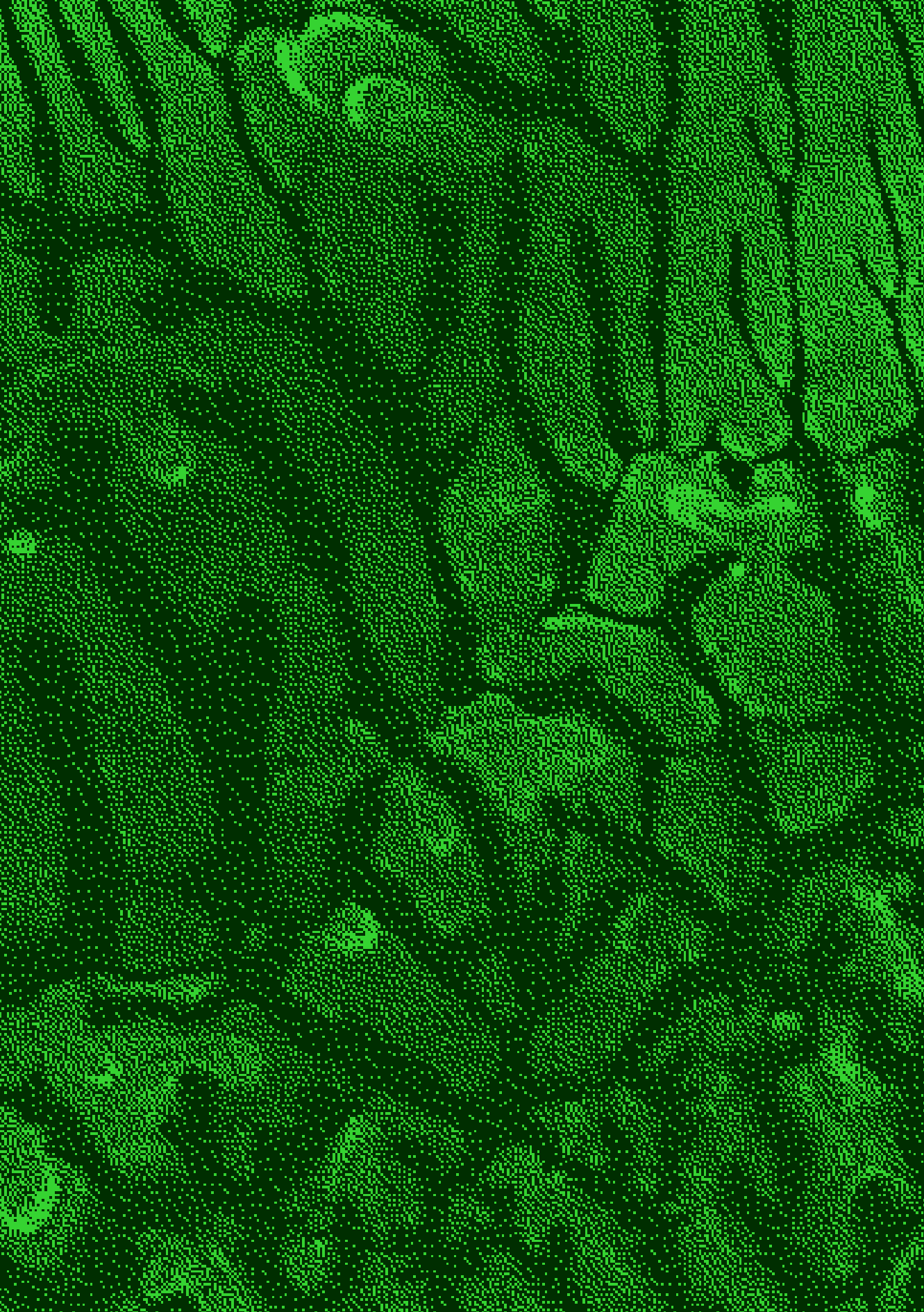
Last.fm is an example of recommendation system with no explanations. However, it has an abundance of other elements such as user created biographies, genre tags and pictures of

artists, not to mention advanced social media features that together effectively work towards the same goals as the dimensions of explanations. Furthermore, Spotify, a popular European music service with very simple recommendation facility, does not provide any explanations whatsoever. Its popularity relies on providing users a minimalistic UI with effective search facility and a functional, high-quality audio streaming. Spotify’s usability and functionality work effectively towards overall satisfaction of the system, making explanations, visualizations or advanced interactivity redundant. Obviously, Spotify’s abilities for helping to find new music are limited, because of very simple recommendation facility, but it can be used as an example of the argument that user trust and satisfaction can be promoted by diverse means depending on the different users’ various needs and desires.

The next step of our research is to conduct an empirical user evaluation of the importance and functions of different UI elements in music recommenders. We are looking for feasible scales of measurement that are drawn from user evaluation of the goals for UI elements in recommenders. User evaluation could be done with modified music recommender UIs where users are given tasks and comparing e.g. how much taking away a UI feature such as an explanation effects to the time the task is completed. It would also be interesting to explore how different goals can be promoted by combining various UI elements, and by assigning unconventional roles for UI elements, e.g. creating visualizations that would reveal the logic behind a recommendation and at the same time give a user a tool to scrutinize.

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**Article II**  
OUT OF THE BUBBLE –  
SERENDIPITOUS EVENT  
RECOMMENDATIONS AT AN  
URBAN CULTURE FESTIVAL

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# Out of the Bubble - Serendipitous Event Recommendations at an Urban Culture Festival

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## ABSTRACT

Advances in positioning technologies have resulted in a surge of location-based recommendation systems for mobile devices. A central challenge in these systems is to avoid the so-called filter bubble effect, i.e., that people are not only exposed to information that is in line with their personal ecosystem, but that they can also discover novel and otherwise interesting content. We present results from a field study of a mobile recommendation system that has been aimed to support serendipitous discovery of events at an urban culture festival. Results from the study indicate that suitably designed recommendations together with access to relevant external information sources can lead to serendipitous discovery of new content, such as new artists, bands or individual songs. Our results also indicate that proximity has little effect on the effectiveness of serendipitous recommendations.

## Author Keywords

Mobile Recommendations, Serendipity, Urban Computing

## ACM Classification Keywords

H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous; H.4.2. [Information Systems]: Information Systems Applications

## General Terms

Human Factors, Experimentation

## INTRODUCTION

Increased sensing capabilities of smartphones combined with advances in positioning technologies have resulted in a widespread interest in mobile recommender systems that tailor their content based on the user's current location, personal profile, activity or other situational factors; see, e.g., [1, 4,

7, 8]. A central challenge in these systems is how to avoid the so-called *filter bubble*<sup>1</sup>, i.e., that people are only exposed to content that is in line with their personal ecosystem. Another major challenge is avoiding the *popularity bias*, i.e., that recommendations and consumption tend to concentrate on popular items instead of enabling people to easily find novel and serendipitous content [3]. To explore how mobile recommender systems can support serendipitous discovery in an urban context, we have developed Sounds of Helsinki (SoH), a novel mobile recommendation system. To evaluate the effectiveness of SoH in supporting serendipitous discovery, we have conducted a field study with 15 participants during an urban culture festival in Helsinki, Finland. In the study, SoH was used to recommend cultural events in the urban environment. The recommendations were augmented with additional media whenever possible. The results of the study demonstrate that suitably designed recommendations can lead to serendipitous discovery of new content, such as artists, bands or individual songs. As part of the study we also evaluated whether proximity to recommended events had an influence on the effectiveness or perceived relevance of the presented recommendations.

## SOUNDS OF HELSINKI

Sounds of Helsinki is a mobile recommendation system for supporting serendipitous discovery of events in an urban environment. Sounds of Helsinki has been implemented following a client-server architecture. The server-side is responsible for generating event recommendations, managing event information and maintaining information about the location of the user. The server-side also acts as repository for any additional media that is available about the performers related to the events. The client-side of the system is web-based and operates in the browser of the mobile phone. The client-side additionally consists of a background script that periodically sends the GPS location of the user to the server. The script is also responsible for triggering notifications about new recommendations whenever they become available. The notifications are given using vibro-tactile feedback and playing an

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IUI'12, February 14–17, 2012, Lisbon, Portugal.

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<sup>1</sup>[http://www.ted.com/talks/eli\\_pariser\\_beware\\_online\\_filter\\_bubbles.html](http://www.ted.com/talks/eli_pariser_beware_online_filter_bubbles.html)



Figure 1. The user interface displaying part of a recommendation on a Nokia N900.

audio alert. To avoid unwanted disruptions, the notifications conform with the current profile of the client device.

The web based user interface is designed to run on a Nokia N900 smartphone, which has a 3.5" touch screen. The interface has two main views, a recommendation listing and an event view. The recommendation listing shows all of the user's recommendations in reverse chronological order, with previously unseen ones marked as new. This view is opened automatically by the client when a new recommendation becomes available. This view can also be opened manually at any time using a shortcut on the phone's desktop. The recommendations can be viewed by tapping on the corresponding item on the listing, which leads to the event view. The event view shows the name of the event and the performer(s), the address of the venue where the event takes place and distance from the user's current position, static maps centered on the user and on the event, and an overview map displaying both; see Fig. 1. In addition, the time and date of the event is shown. For recurring events, all future showings or performances are also listed. If the event is sold out, this is also indicated. For events that we were able to locate suitable media for, the event view enabled the user to listen to music samples of the artist, or to view embedded YouTube videos of the artist.

Sounds of Helsinki currently integrates two different recommendation techniques. Both recommendation techniques restrict the recommendations to events that take place during the current day and which have not yet started. We refer to the events satisfying these criteria as the *candidate pool*. Both recommendation techniques assign a weight  $w_i$  for each of the events  $i$  in the candidate pool  $C$  and select the event to recommend through weighted random sampling. The first technique, `RANDOM`, assigns uniform weights for all events in the candidate pool. The second technique, `LOCATION-BASED`, assigns the weight based on proximity to the event. Specifically, if  $d_i$  denotes the distance in kilometers to the event  $i$  from the user's current location, the `LOCATION-BASED` recommender uses  $\exp(-d_i)$  as the weight of event  $i$ . As sold-out events would be associated with information about artists and potentially also with media, we did not filter out sold-out

events from the candidate pool before generating recommendations.

## FIELD STUDY

To evaluate the effectiveness of Sounds of Helsinki in supporting serendipitous discovery, we have conducted a field study during the Helsinki Festival 2011, a yearly cultural festival taking place in Helsinki, Finland. The duration of the festival is approximately two weeks, during which numerous cultural events, such as music, dance, cinema and theater performances take place at different locations throughout the city. For conducting the user evaluation, we recruited two groups of people that described themselves as active listeners of mobile music and avid event-goers. The participants were aged between 24 and 45. The first group ( $N = 8$ ) participated in the study for two days, while the second group ( $N = 7$ ) participated for three days that did not overlap with the days of the first group. The participants were provided with Nokia N900 smart phones equipped with prepaid SIM cards for the duration of the study, and they were rewarded with tickets to one of two selected events during the festival. The reward events were excluded from being recommended by our system.

To avoid disrupting participants during night or working hours, recommendations were only generated between 2 p.m. and 10 p.m. To preserve battery of the client device, GPS location updates were sent to the server at five minute intervals. The time between successive recommendations was randomly sampled between 40 and 80 minutes. The algorithm that was used to generate recommendations was chosen randomly each time a new recommendation was made. For each recommendation, the participant had the option of rating the recommendation using *thumbs up* and *thumbs down* buttons.

To supplement the thumbs up/down ratings, at the end of the field study we collected post-hoc survey responses. Specifically, for each participant, we replayed the event recommendations that were shown to him/her during the study. For each recommendation, the participant was asked to respond to a six item questionnaire that measured whether the participant saw the recommendation, how good and serendipitous the recommendation was, and whether the recommendation influenced the participant's behavior or not. The question items that were included were adapted from the user-centric recommendation evaluation framework proposed by Pu et al. [6]; see Table 1 for the items that were included in the questionnaire. Responses for all items were elicited using a 5-point Likert scale that was anchored at "completely disagree" (=1) and "completely agree" (=5). After completing the questionnaire for each event recommendation, the participant was asked to complete a ten item end-questionnaire measuring the overall usefulness of the system and its capability to support serendipity; see Table 2.

## RESULTS

### Events and Recommendations

In total, 241 recommendations were made in the field study. Most of the recommendations (212, 88%) were viewed by

the participants, which indicates that the system was effective in increasing awareness of available events. In total, recommendations were made for 68 different events. Out of 241 recommendations, 95 (39%) had either streaming music or a YouTube video associated with them. The media was consumed at least once in 50 of the 95 cases (53%), but more than once only in 5 cases. Of the recommendations that were viewed, 74 (35%) were rated as good (thumbs up), 46 (22%) as poor (thumbs down), and 92 recommendations (43%) were not rated. No statistically significant differences were observed in the ratings between the `RANDOM` or the `LOCATION-BASED` recommendations. The median distance to events recommended using the `RANDOM` technique was 2.9 kilometers from the user's current location. For the `LOCATION-BASED` recommendations the median distance was 2.0 kilometers.

### Influence of Recommendations

Table 1 summarizes responses elicited to questions measuring the relevance and goodness of individual event recommendations. We used non-parametric ANOVA to compare the responses to the recommendations generated with the `RANDOM` method and the `LOCATION-BASED` method. The comparison revealed no statistically significant differences between the two recommendation methods. We separately evaluated whether distance to recommended events influenced any of the responses. This analysis was conducted using one sided t-tests assuming unequal variance. Before analysis, the distance values were normalized by applying a logarithmic function on them. The analysis did not return any statistically significant effects, which suggests that proximity had no influence on perceived relevance or effectiveness of recommendations in our study.

The responses to the questionnaire indicate, first of all, that most of the recommendations were for artists/performers that were previously unknown to the participant and for events that the participant had not heard of before. Together with the high consumption rate of additional media, the results thus indicate that SoH was effective in supporting serendipity. However, the responses also indicate that the event recommendations were considered neither interesting nor uninteresting, implying a trade-off between relevance of recommendations and support for serendipity.

The recommendations that were presented were considered neither good or bad in terms of their timeliness. The responses also suggest that the recommendations had little impact on the behavior of the participants. Comments of the participants suggest that one of the main reasons for the limited impact of the recommendations on their behavior was related to pre-planning of the day's schedule before being exposed to the event recommendations. Some of the recommended events that the participants considered interesting had already been sold out which prevented them from having an influence on the participant's behavior.

Table 2 summarizes the responses to the questionnaire measuring the overall goodness of the system. The responses indicate, first of all, that, while individual event recommendations were not considered particularly relevant, overall the

participants were satisfied with the system and the support it provided for determining which events to attend. Similarly to the responses to the individual event recommendations, the participants did not consider the system to have a significant influence on their behavior.

### DISCUSSION AND CONCLUSIONS

We have presented Sounds of Helsinki, a mobile recommendation system for supporting serendipitous discovery of events in an urban environment. Results from a field study with 15 participants, conducted during an urban culture festival, indicate that SoH is effective in supporting serendipity. However, the results also indicate that the recommendations were not considered particularly interesting or relevant. While personalization techniques could be used to improve the interestingness of recommendations, this would easily decrease the effectiveness of SoH in supporting serendipity. A potential solution would be to use personalization techniques not only for determining what to recommend, but to determine when the user is more likely to be interested in novel and serendipitous content.

The results of the study also indicated that proximity to events had no influence on the perceived goodness of the recommendations. The city of Helsinki, where the study was conducted, has a good public transportation system and many central culture venues are within walking distance from each other in the city centre. For a person located outside the city center, this means that it will take him or her approximately equally long to get to any venue. On the other hand, for someone already in the city centre, most culture venues can be reached within 15 minutes by foot or by public transportation. Given this, the effort required to get to an event is likely to be similar for events that are recommended using either of the recommendation techniques. The similar rate of positive and negative responses for the two recommendation techniques further supports this interpretation. This finding is in line with results from studies in location-based personal information management [5] and mobile marketing [2] which have shown that user preferences regarding location are complex, extending beyond geographic proximity and depending on a multitude of factors ranging from user plans to movement routines and social geography of an area.

### Acknowledgments

The authors wish to thank Helsinki Festival for providing the reward tickets. This work was supported by Aalto MediaFactory and EIT ICT Labs.

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	RANDOM	LOCATION-BASED
	Median (IQR)	Median (IQR)
I am sure that I saw this recommendation.	5 (2)	5 (1)
The recommendation was interesting.	3 (2)	3 (2)
I was already familiar with the artist.	1 (3)	1 (2)
I had already heard about the recommended event.	1 (1)	1 (1)
The recommendation was presented at a suitable time.	3 (2)	3 (3)
The recommendation affected my behaviour.	1 (1)	1 (1)

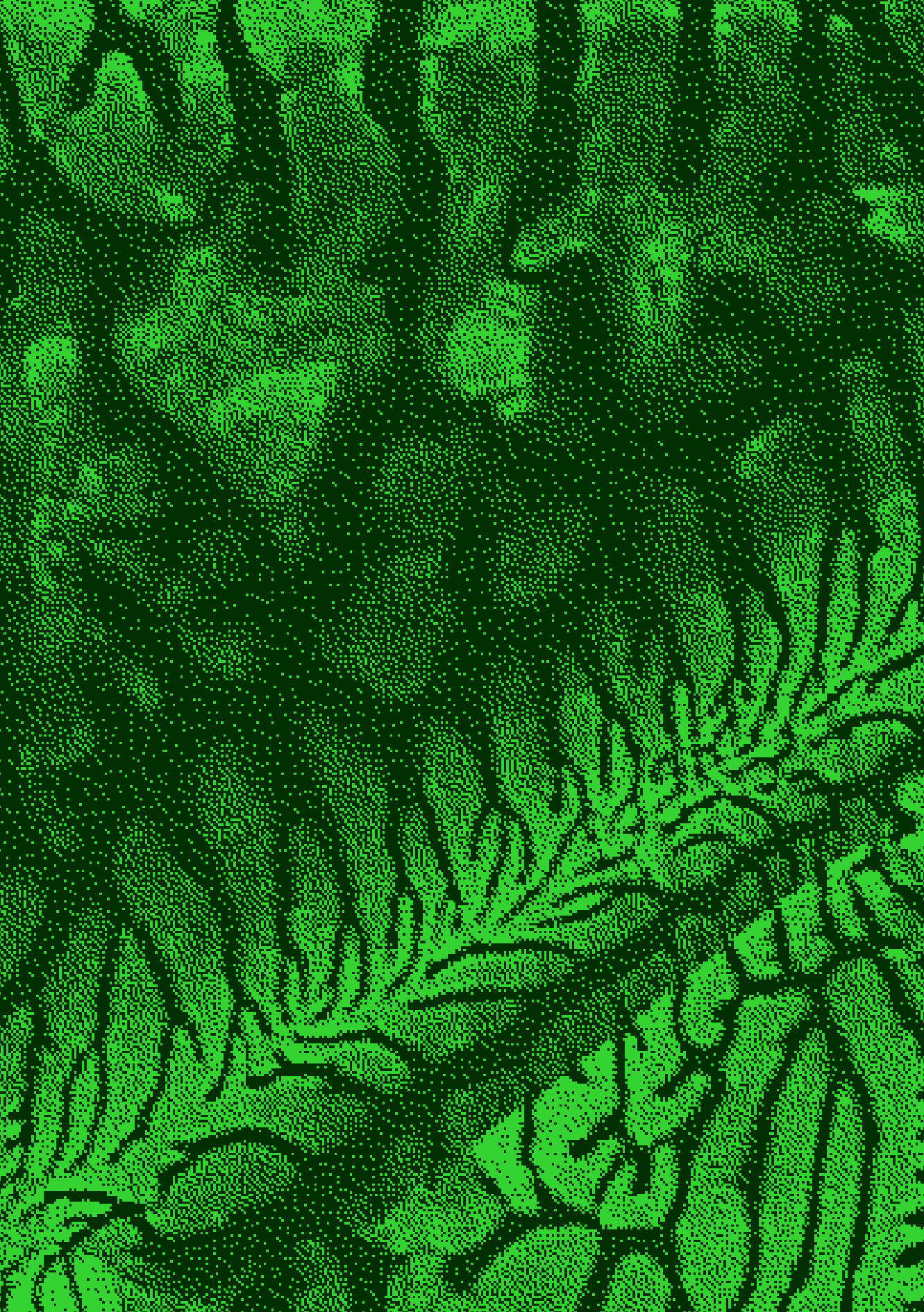
**Table 1. Summary of per-recommendation questionnaire results. The questions have been translated from Finnish.**

	Median (IQR)
I enjoyed the [listening to or watching] the artists/bands of the recommended events (through media samples or attending the events).	3 (1.0)
The recommendations helped me find new artists.	3 (1.5)
The artists/bands related to the recommended events were not previously familiar to me.	3 (2.0)
I found the recommended events interesting.	4 (0.5)
The recommended events did not interest me.	2 (1.0)
The recommended events were similar to each other.	2 (0.5)
The recommendations were timely	4 (1.0)
The recommendations affected my decisions to attend events.	2 (2.0)
When I use the service, I feel that it supports me in trying to find content or events that I like.	4 (1.0)
Overall, I am satisfied with the recommendations made by the system.	4 (1.0)

**Table 2. Summary of end-questionnaire results. The questions have been translated from Finnish.**

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## **Article III**

# PAINTING THE CITY WITH MUSIC: CONTEXT-AWARE MOBILE SERVICES FOR URBAN ENVIRONMENT

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## Painting the city with music: context-aware mobile services for urban environment

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Music business is undergoing a tremendous change in the early twenty-first century. Similarly, the landscape of music delivery and discovery is drastically evolving because of new technologies. This paper presents SoundAbout, a platform for location-based music services. It enables new applications running on mobile phones and desktops. It allows users to share music and information about music they listened to in different locations. With SoundAbout people can experience music related to the different locations in various ways, for instance by seeing what music has been listened in different districts of the city during a particular time span, select a list of favourite artists or songs and attach that list in favourable location, and see who else in different locations share their taste in music. Our goal is to not only support musical serendipity, but also affect the city culture. With context-aware music services, it is possible to offer people new kinds of urban audio experiences. In this paper, we apply characteristics of psychogeography and graffiti painting as an inspiration for the design of service concepts for the platform.

### Introduction

Imagine a city where graffiti wasn't illegal, a city where everybody could draw whatever they liked. Where every street was awash with a million colours and little phrases. Where standing at a bus stop was never boring. A city that felt like a party where everyone was invited, not just the estate agents and barons of big business. Imagine a city like that and stop leaning against the wall – it's wet. (Banksy 2006)

Take the Banksy quote above and replace 'colours' with 'songs' and 'phrases' with 'sounds'. Imagine that you have a spray can full of music, millions of songs you can use to paint the city with music, take over the city by dropping music in places meaningful to you, all over the town and share those location, time and music combinations with your friends, or with anybody to explore, enjoy and modify. This thought experiment is an example of services that new mobile technologies make possible and what might become commonplace in the future through mediators such as the SoundAbout platform we introduce in this paper. There are reasons to believe that this is both feasible and desirable in the near future.

Music experience is essentially contextual. It cannot be taken apart of the situation it is listened to, owing much to the physical and social surroundings that accompany it. Imagine sitting in a tram alone, listening to a violin concerto at full blast. The experience creates a contrasting audio soundtrack to the landscape passing by, taking the passenger somewhere else, in an escapist psychological bubble (Bull 2004). Or, when listening in company, one's musical selections usually differ from those listened alone, because music

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works as social glue. Music takes us from the moment and connects us to it. Music connects us to others and distances us from them. One of the most important functions of music in contemporary society is mood regulation (Levitin 2007; Saarikallio and Erkkilä 2007). Most music listeners might take pride at being able to select the right music to achieve particular emotional states, even if they talk about music mostly as an enabler to do things.

The emergence of mobile and ubiquitous computing technology has created a hybrid space – a virtual layer of digital information and interaction opportunities that sit on top of and augment the physical environment (Bilandzic 2010). Augmented and virtual realities enable us to construct new fabrics of reality by technology to eradicate present limitations of space and time, and designers and researchers today explore ways to enhance and empower people's situated real world experience with digital media.

New services do not just promote novelty function, but also survival in the digital jungle. Today's information abundance and diversity of products has made recommendations increasingly important in helping people to find the content they are interested in (Celma 2010). In computer science, the study of recommendation systems has spawned considerable interest and even a dedicated conference series started in 2007 (ACM Recommender Systems; <http://recsys.acm.org/>). Music is one of the most important media in this development, as massive online libraries of music have become available for free or at a minimal cost (e.g. <http://pandora.com>, <http://spotify.com>) and average personal music collections have exploded to cover hundreds and hundreds of digitally stored albums and tracks (Brinegar and Capra 2011). We can assume that nearly all music ever recorded is already available in some form online. The problem for the consumers is how to find the most interesting and serendipitous, positively surprising new music (Adomavicius and Tuzhilin 2005). For us, the channels for music recommendation and discovery are diverse and are not restricted only to dedicated digital music recommendation services and technologies. Thus, recommendation also covers radio, TV, blogs, print media and social recommendations such as friends or strangers recommending music either in private or public places, such as bars or clubs. Today, radio and word-of-mouth still remain the most important channels of discovering new music (Nielsen 2012).

In this paper, we present our framework for experimental mobile music services called SoundAbout. It is an example of augmenting the urban soundscape and a means for appropriating the public space. Our framework can be seen as a contextual recommendation system, based on content-based recommendations and collaborative filtering (social recommendations). SoundAbout is a roof concept for several music services accessible with mobile devices capable of accurate location tracking and Internet communication. It combines extensive music database, location data, recommendations and a map application. Other information types, such as various types of user-generated information (e.g. user-created descriptors or tags for songs), may also be considered as feeds for having an effect on the music offered to users.

There are several goals for the SoundAbout project, of which some are design-oriented (generating technology) and some research-oriented (generating knowledge), which is typical of human–computer interaction (HCI) research (Fallman 2003). Therefore, our approach could be described as HCI *research through design* endeavour. As an inspiration for design, we apply concepts and phenomena studied by social sciences and design research (Krippendorff 2006). We are connected to cultural studies on several aspects, by the necessity of understanding the existing and paralleling cultures of technology usage, and the desire to shape the practices of everyday media use into something new.

On the research side, the prototype will be used as a research tool to investigate the phenomena of HCI and social aspects of location-based tools that allow people to consume, create and share audio content. Design goals relate to designing services that empower people in their everyday lives, for example by offering people meaningful musical experiences in very ordinary everyday situations, such as when walking, travelling in or waiting for public transit, and making moments in everyday life special by offering musical serendipity. Moreover, design goals include developing new kinds of music-service concepts by prototyping and gathering expert and user opinions in iterative development cycles, resulting in improved designs. We aim to provide people tools to control and modify their everyday lives by giving them ubiquitous, personalizable and context-aware audio tools.

At the core of the platform's concept development is to explore rich and heterogeneous collections of musical content together with location-aware technologies. We want to understand how to create rewarding and pleasantly surprising use experiences for the users, and how to waive an enticing fabric of sound over the existing layers of urban soundscape. In the ethos of 'social media', we aim at the sharing of experiences by using music and contextual information, and the city as an ever-evolving canvas. Considering geographical space to be a canvas that allows the inscription of personal narratives, desires and memories offers a powerful instrument for individuals and communities to co-create their environment and to collectively organize and share experiences.

Research questions include: How do our ideas of empowering the urban music consumer with new technologies change the cultural landscape that exists this far? What are the most feasible contextual factors for personalized music recommendations? How to offer users location-based music that matches user's taste or broadens it by offering musical surprises? How do differing music consumption patterns reflect the different identities of the districts of the city or a larger area? Let us start from the functions and appeal of 'private' music in physical, public space and how people construct their everyday lives within the wider societal structures.

### **Background: appropriation of public space with sound**

The importance of appropriating the physical and social space for private use is reflected through the thoughts of several authors in the literature. de Certeau (1984) provides a useful concept pair, the dichotomy of 'strategy versus tactics of space'. This is useful for envisioning how people could take over the public space by linking music with contextual information, such as location and time. Other phenomena we find useful are *psychogeography* and *graffiti* that will be introduced later on. De Certeau's 'strategy' refers to infrastructure, authority and institutions, which set the frame wherein people negotiate their everyday life, using various 'tactics'. Tactics refer to the creative intelligence that we employ to ensure our environment works to meet our needs. Tactics allow ordinary people to subvert the all-pervasive pressures of consumerism, economics and politics, and to regain their individuality. While Marx (1971) counts upon social uprising as the catalyst for change, de Certeau finds empowerment in the small details and qualitative differences of everyday culture. For de Certeau, the longing for a revolution or societal utopia has been replaced by creative survival at a very basic level. Consumer society cannot be avoided and mainstream culture dictates, but consumers can create personal meanings by the manipulations of consumerist technologies, and the active roles they take through the consumption of objects and media (de Certeau 1984). Applications such as those based on SoundAbout can be designed to allow people to use different

audio-geographical tactics to make the everyday urban living more interesting and personal. Empowerment here means augmenting people's experience of the city they are visiting or living in.

There are hundreds of millions mobile phone users moving around the metropolises of the world, but most of them will surely attest to the absolute uniqueness of their portable music player's library. For each of them, moving through the very ordinary spaces of the city can become a completely singular and poetic experience. The addition of a personal soundscape makes de Certeau's 'chorus of idle footsteps' (e.g. unavoidable everyday travelling such as commuting) literal and immediate (de Certeau 1984). The city becomes stratified with psychological experiences of what has been called 'eight million cities in this naked city. They dispute and disagree. The New York City you live in is not my New York City. How could it be? This place multiplies when you're not looking' (Whitehead and DJ Spooky 2003).

Michael Bull (2000, 2004, 2007) is one of the most prominent scholars in the field of cultural research on mobile music in urban contexts. He is interested in the ways personal music players change how people construct their social worlds. Until recently, people used personal music players, such as Walkmans, to isolate themselves from others, but with digital players (iPods, etc.) and mobile music services (Spotify, Last.FM, Rdio, etc.), people are also increasingly sharing their musical experiences, music collections and listening behaviours. That changes our relationship with music and with each other. For Bull, appropriation of space is not only occurring physically, but mobile media technologies also have the capacity to create a non-spatialized conceptual space or a subjective aural private bubble. He analyses this phenomena from the perspective of the mobile user:

As geographic notions of personal space become harder to substantiate and negotiate in some urban environments, the construction of a privatized conceptual space becomes a common strategy for personal stereo users ... [they] appear to achieve a subjective sense of public invisibility. The users essentially 'disappear' as interacting subjects withdrawing into various states of the purely subjective. (Bull 2004, 284–285)

By listening to music with headphones people create a non-space within the public space. In situations such as commuting, music provides a soundtrack for the often monotonous everyday travel and landscape. Our framework aims at connecting music in places, or routes of travel, and making possible a new, aesthetically pleasing sensory layer. Bull (2004) has studied communication and building of identities through the use and appropriation of mobile music technologies, whereas we aim to offer a technological framework that people can use for appropriation of public space. Bull studies existing technologies whereas our focus is on the design and development of future technologies. In both the cases, experience of public space is being modified and taken over by mobile music technologies. Also, we share the view that music adds something tangible to a place, capable of being modified and shared socially. By suggesting the SoundAbout platform, on the one hand, we add to Bull's observations of urban soundscape a personal audio bubble in a public space and, on the other hand, social sharing of music, a few additional dimensions: context-sensitivity and possibility to make the urban soundscape one's own by planting music, location and time combinations. But before presenting our platform and service concept examples, we introduce two inspirational practices and phenomena: *psychogeography* and *graffiti*.

The concept of psychogeography was defined and developed by Guy Debord in 1955 in the leftist journal *Potlach*. Debord was a French Marxist theorist, writer, film-maker and founding member of the groups Lettrist International and Situationist International.

Psychogeography can be seen as a pseudo-academic endeavour of ‘the study of the precise laws and specific effects of the geographical environment, consciously organized or not, on the emotions and behaviour of individuals’ (Debord [1955] 2006). Another definition, more suitable for our purposes for modifying the urban landscape:

a whole toy box full of playful, inventive strategies for exploring cities ... just about anything that takes pedestrians off their predictable paths and jolts them into a new awareness. More broadly, it is the state or quality of being aware of the urban landscape. (Hart 2004)

One practice in psychogeography is the making of psychogeographic maps that are used as guides for experiencing the urban landscape in deviant ways. Psychogeographic maps can be often seen as pieces of art, as well. For example, modified London metro map appeared in posters of a demonstration in 2003, with the station names replaced with the capitals of different countries (Wikipedia 2011). The poster had a text: ‘Meet you at Jerusalem 3.33 pm’. Another practice is making maps for walking the city in a way different from usual everyday practices. Another example from the same city is London Cross, a straight-line walk across London. As psychogeographer Paul Lyons puts it: ‘If you walk across a great city such as London in two straight lines, south to north and east to west – a cross-section – what do you find?’ (London Cross website 2011, <http://www.londoncross.co.uk/>).

Probably the most famous psychogeography map is Debord’s (1957) *Guide Psychogéographique de Paris* (Figure 1). It is an example of mapping the atmospheric unities of a city on the basis of ideas of the Situationist movement. The map of Paris has been split into different areas that are experienced as distinct unities. The mentally felt distance between these areas is visualized by spreading out the pieces of the cut up map. By wandering, letting oneself float or drift, people can discover their own ambient unities of

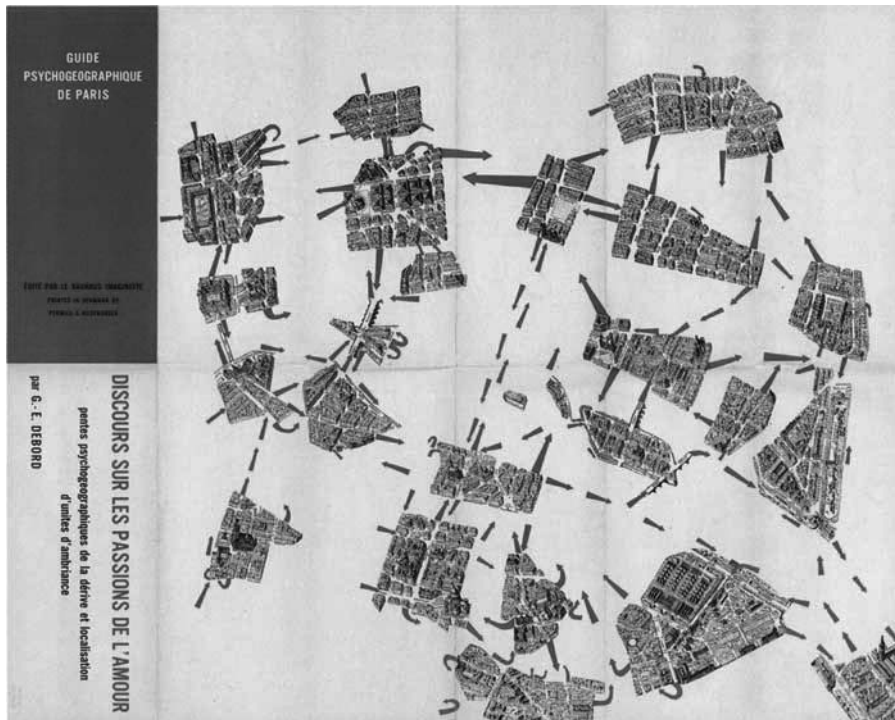


Figure 1. Guide Psychogéographique de Paris.

the city. Arrows indicate the most frequently used crossings between the islands of the urban archipelago separated by flows of motorized traffic (van Tijen 2011).

For its Situationists founders and its modern practitioners alike, psychogeography is essentially fuelled by dissatisfaction with urban environment and how it is designed. At its core is a strong desire to make the everyday urban living more interesting. This strikes a powerful chord with what we are suggesting with SoundAbout platform. We aim at giving people tools for creating and sharing new meanings for places that are created by user-driven action, without political or economic top-down planning.

Graffiti is probably the most visible manifestation of grass-roots modification of urban space. Some see it as an art form, others as mere vandalism. It can also be conceived as one of the tactics for empowering appropriation of the public space, and a psychogeographic practice. Sociologist Jeff Ferrell has studied graffiti widely (1996, 2001; Ferrell and Sanders 1995). For him, graffiti subcultures are aesthetics-driven communities that mix innovation, crime, artistic activities and questioning the authorities. Graffiti crime is not ordinary crime; it belongs to the *crimes of style*: painters challenge the aesthetics of authority, and those who have defined urban environment and its ideal organization and rules (Ferrell 1996). Public space is not just a means to make money, but also a forum for identity building, social observations and communality. Different actors have different understanding of urban spaces and their functions, and conflicts and controlling actions are thus unavoidable. Public space is always a cultural space, a place of contested perception and negotiated understanding, and a place where people of all sorts encode their sense of self, neighbourhood and community. Therefore, the occupation of public areas remains as much symbolic as physical (Ferrell 2001). For those in power, at stake is their dream, a dream of spatial and perceptual control that others (graffiti painters, guerrilla gardeners, etc.) might consider a dystopian nightmare – a potential police state of a particularly damaging sort. For Ferrell, anti-graffiti policies mean cleansing the public space of marginalized populations, and cleared of uncomfortable reminders of social otherness they present (Ferrell 2001).

For the painters, graffiti has four main motivations (Snyder 2009). Most of the graffiti painters stress the importance of working together, and for many, *social motivations* are the most important incentive to start painting. Although there are also famous solo painters, such as street artist Banksy, a smallish group of painters, *crew*, is the most common unit of action. Crew is an informal group of painters doing graffiti together and its tag is usually painted in side of the *pieces*, graffiti works. Communicating crew's own style to other painters and crews is an important motivation for doing pieces (Ferrell 2001; Snyder 2009). Crew's fame depends upon each of the members being active, so a productive painter is valuable for the crew. Commitment in many cases is so strong that crew can function as individuals' primary social group (Austin 2001, 120). Collective levels include street-art-related demonstrations, weblogs and Internet discussion forums.

*Personal motivations, visibility and fame* build on painter's signature, *tag*. Personal tag is used in achieving respect inside the subculture. The more a painter spreads his tag, the more street credibility he gets, but only within the subculture, because those outside of it cannot recognize the different tag styles and other cultural conventions. 'He's all over the city', is a widely used statement of respect. Building long-lasting fame is often hard: painters change their tags to avoid sanctions. Security firms and police keep photo archives that are used to identify painters' works, and based on the stylistic evidence, painters can be punished for pieces painted years back (Ferrell 2001; Snyder 2009).

*Aesthetic motivations* are built around the need to express oneself, the desire to create something own and unique. Ambitious painters develop their style constantly, combining

various techniques and conventions. Aesthetic motivations become typically more important as the painting career gets longer, and the focus moves towards doing polished pieces in undisturbed places. In media the aesthetic dimension is often emphasized. Most painters have been fed up of stereotypical discourse asking, 'Is graffiti a true art form?' (Ferrell 2001; Snyder 2009).

*Destructive motivations:* graffiti has an intrinsic dimension of rebellious and destructive vandalism as well. In some cases, motivation for doing graffiti is simply an urge to cause damage or to provoke police or security firms (Ferrell 2001). Many painters openly admit this: 'Graffiti is destructive, but that is just an indirect answer to the public destruction that advertising has brought. If you study graffiti as an urban phenomenon, it started same time as mass marketing' (Painter 'Grey' in Labonté 2003, 170). In SoundAbout, we want to offer an alternative to the urban soundscapes people have to encounter in shopping malls and other spaces designed by and for market forces. The platform must be built as an open system, so that innovative uses through user creativity are supported.

Graffiti is essentially illegitimate, and that is the main difference between graffiti practices and SoundAbout framework. We aim to provide music lovers discreet, invisible and legal ways to take over places and spaces. Still, there are several mutual characteristics of our planned audio framework and graffiti. Graffiti is ubiquitous, and that is the goal of our framework as well. Graffiti can be considered as the art and expression of the untrained. Similarly, our framework is meant for everyone, and the interactions should be designed so that using SoundAbout would be as easy as holding a can of paint. The differences between graffiti and SoundAbout are also numerous. Graffiti aesthetics are often intentionally rude and in-your-face, perception is involuntary and unavoidable, and based on sight. SoundAbout is designed to be discreet, its perception is voluntary (turning the app on, wearing headphones on) based on sound and invisible. Both aim at creating people's own spaces inside the city and upon the public urban infrastructure, and filling the ever-present desire and need of marking one's own territory. We conclude our comparison by arguing that although graffiti and SoundAbout are in many ways different practices of augmenting urban space, graffiti painters' motivations and the analogue and comparison of graffiti and SoundAbout is fruitful and adds inspiration in designing and researching our platform and its service concepts; graffiti give us directions to build same kind of need fulfilment opportunities in our system. Some of the motivations for using SoundAbout are clearly overlapping with those of graffiti: personal, social and aesthetic, and we will handle those later on when presenting the service concepts. Along the design process, we will organize co-design workshops where user needs, desires and motivations are mapped. Mobile applications are designed according to those user motivations, and they are user-tested in realistic contexts to ensure the user input in every phase of the process.

### **Related systems**

Recommendation systems have traditionally been two-dimensional: users are recommended either items, such as books and films, or other user profiles, as in dating services. Additional contextual information types have the potential for providing more accurate, more interesting and serendipitous recommendations for mobile media users' variable conditions (Adomavicius and Tuzhilin 2005; Celma 2010). This means adding information not only about time, place or company user is in, but also more marginal information types such as weather conditions, biosignals (heart rate or skin conductivity) or activity (e.g. running, driving, climbing) (see e.g. van der Zwaag, Westerink, and van den Broek 2009).



**Commercial examples**

There are only a few examples of contextual music recommendation services to be found yet. In commercial music recommendations systems such as Last.FM, Pandora and iTunes' Genius (see Figure 2), users receive music recommendations based on various



Figure 2. Screenshots of Pandora and Foursquare.

factors, including on track, artist or user similarities (Celma 2010). However, these are not designed for ubiquitous use and provide limited or no use of context or location information. For instance, Last.FM apparently utilizes location information only to recommend live music. Spotisquare is an example of existing mobile contextual music service. It allows users to connect Spotify playlists with places, typically bars and clubs, using their Foursquare accounts (see Figure 2). However, users must link places and playlists manually, and there are no automated recommendations (Spotisquare website 2011, <http://www.spotisquare.com>).

### **Research prototypes**

Various research prototypes of music recommendations systems for mobile devices exist. They aim to provide people tools for serendipitous, contextual music experiences, however, they are not taking full advantage of contextual information. We will next provide examples of the research prototypes.

SoundPryer (Östergren 2004) is an application running on Wi-fi-enabled mobile phones and designed for sharing music between cars in proximity. Push!Music (Jacobsson et al. 2006) is a prototype wireless peer-to-peer mobile music player with sharing capabilities. This player enables users to push songs to each other's mobile terminals. In user study, it was shown that the participants had two main reasons for sharing the songs: dissemination where the sender liked the songs and wanted others to hear it as well, and recommendation when the sender sent a song that he believed the receiver would appreciate. BluetunA (Baumann et al. 2007) is a music-sharing application running on mobile phones that allows users to share information about their favourite music with other users within Bluetooth range. Users may also receive recommendations from the Last.FM web service, which allows reaching more people and providing more accurate recommendations than a system based on Bluetooth. BluetunA is not focused primarily on the sharing of music content. BluetunA represents a lightweight application aimed at increasing people's awareness of their surroundings.

Bubbles is a wireless peer-to-peer application for sharing multimedia content on mobile devices (Bach et al. 2003). When another mobile device is in the range of the wireless network card, it is possible for these devices to share music and playlists. This application allows the user to choose between listening to streamed music or downloading it. Bubbles does not provide recommendations. SuperMusic (Lehtiniemi 2008) is a prototype streaming context-aware mobile music service. It utilizes 2,00,000 track music catalogue including two different music recommendation methods in addition to social interaction of the users. The prototype aims to find new music for the users out of the online music catalogue using two criteria: similarity and the context of the user. In Supermusic, contextual recommendations are calculated from users' whereabouts using GPS (Global Positioning System) and cell ID, together with time. The users can rate the recommended music and let the system learn in order to provide better recommendations. IM4Sports (Wijnalda et al. 2005) is a portable adaptive music player aimed for sports exercise use. Context data, such as heartbeat and stride speed, are collected and used for giving recommendations or adjusting the tempo of a song. The context data have to be transferred to a PC for analysis and the recommended playlists need to be transferred to the mobile device before the exercise. Lifetrak (Reddy and Mascia 2006) uses a context-sensitive music engine to drive what music is played. The context engine is influenced by the location of the user, the time of operation, the velocity of the user and urban environment information such as traffic, weather and sound modalities. However,

recommendations in Lifetrak do not consider the user's listening habits; neither can users change the predetermined playing order of the music tracks.

## **SoundAbout platform**

### *Designing urban audio experiences*

Our design process included several phases described in the following paragraphs: laying out the abstract requirements, envisioning concepts, testing concepts in focus groups, implementing concepts as a software prototype and testing the prototype. On a conceptual level, there are several categories of information required to build a location-based music platform. We need to collect information about played music, location and the user. For the interface, we have requirements for visualizing the appropriate information and most importantly providing easy access to music. For the service to be useful and provide social networking capabilities, for instance, we need to build up a decent user base that is willing to utilize our platform. With SoundAbout, we aim to collect the location data automatically and recommend music in real time. The recent revolution of mobile Internet and new massive subscription-based online music catalogues such as Spotify and Rdio have made possible the development of such services legally.

A user focus group was held in order to get feedback for the service concepts envisioned by the authors of this paper. The group consisted of eight active mobile music users aged 18–40 years. The users saw Hotspots as the most feasible of the concepts, most flexible and most rewarding for them, as it provides users multiple tools for modifying the urban soundscape and experiencing places in a personalizable and discreet way. A version of Hotspots was therefore chosen to be the first concept to prototype.

### *Implementing the platform*

The mobile-use cases are not only the most interesting, but also the most challenging. While current mobile technology can transfer, process and store music content without difficulties, there are still technical bottlenecks in the process. These concern mostly battery life when using 3G connections and GPS receiver and the synchronization interval in client–server protocols. These considerations must be kept in mind while trying to design a pleasurable user experience for mobile music in each proposed service. The choices over technology influence what we can get out of the system. For instance, there are multiple solutions to positioning (GPS, cell ID, network, Wi-Fi), which all have different pros and cons (accuracy, power consumption). Potential design parameters from the application development point of view are presented in Table 1. On the ethical, normative side of design research, our platform should ideally be offered for free as a mobile phone and web application in an easy-to-use, portable form across different manufacturers' technical platforms and across cities over the different continents, making its as ubiquitous as graffiti painting.

### *Service concepts*

SoundAbout platform supports various service concepts. We present here three concept examples that we are planning to implement as demonstrators for the platform. All service concepts aim to empower the everyday lives of users differently, and by offering means of appropriation, modification and bricolage of the urban spaces by audio tools. Location-aware music services have the potential of offering people new ways of appropriation of

Table 1. Design space parameters.

Location	Time	Music meta-info	Information about user	Need for visualization	Content availability	(Minimum) user base	Mobile app requirements
GPS coordinate	Seconds	Artist	Name	Path (time-space)	Identifier (genre, title, etc.)	1	None
Street address	Track duration	Track title	User name	Point	Link outside (Last.FM, etc.)	2–15	GPS
GSM positioning	Hours	Album name/ version of recording	Age group	Area/district	Preview (e.g. 30-second Last.FM link)	15–30	Upload data
Cell ID	Time of day	Track number	Sex	Taste aggregate	Music content (researcher made ad hoc library)	31–100	Personal music player, upload data
District/area	Day	Publication year	Info on user's other service accounts (user names)		Massive online library: Spotify, Pandora, Last.FM, etc.	100–1000	Download and/or stream music
City/municipality	Week	Composer/music or lyrics	User-given info on taste		Ultimate library: all the music content available	1000–10,000	
Country	Month	Lyrics	Contact (email, <i>Twitter</i> , etc.)			> 10,000	
	Season (spring, etc.)	Album art					
	Year	Pointer (Spotify, all music guide, etc.)					

the public space, different from practices of, for example, graffiti painting. In our system, taking over public space by music (specifically by headphone listening) is invisible, personal and a much more discreet way of appropriation of space than graffiti. For our purposes, graffiti serves as an inspiration and a fruitful metaphor: *painting the city with sound*, and for us, as researchers and designers, it is useful to take a look behind the graffiti, i.e. *piece on the wall*. SoundAbout extends the ways of appropriation to the social sharing of music: users could drop and scatter music at specific places or geographical areas.

### *Musical Hotspots*

Musical Hotspots is a roof concept for various ideas about user-chosen location and sound and/or music combination. Users can leave sounds in different locations to create hotspots and trails of sound marking music that is listened in certain areas. Those location/sound combinations evolve, change and fade over time to be found by other people, resulting in a city scattered with sound. For example, users can leave a song or record a piece of speech or that place's soundscape by tagging the location information to that sound/music combination, to be found for a certain time window, just like graffiti pieces that are essentially transitory. User motivations for adding sound to a place are multiple. Some places remind us of a certain piece of music, sometimes it would be nice to tag a special place and what happened there, with a piece of music, and share those with meaningful others. Research motivations are centred in investigating what kinds of appropriation strategies people use in making parts of the public space their own by audio/location tagging. Beyond and with 'taking into possession', appropriation strategies may include 'articulation of own identity' and 'distancing from majority'. These strategies connect with de Certeau's (1984) dichotomy of 'strategy vs. tactics of space': infrastructure, authority and institutions set the frame wherein people negotiate their everyday life.

Our goal is to apply psychogeographic ideas for our map application visualizations. Maps have several functions. Maps visualize multiple sources of data that can be filtered using personal preferences, for example, 'places where I spent time with my girlfriend in Summer 2011 listening Miles Davis'. Music dropped to places give new, shared meanings to the places and maps are used to visualize these (see Figure 3). Maps can show routes or 'music walks' that local artists, event organizers, tourists or locals may want others to experience. We take psychogeography's central point: 'how this place feels' to communicate 'I felt like this listening this music in that place in that time . . .'

### *Musical Treasure Hunt*

Musical Treasure Hunt owes much to geocaching, which is the practice of hiding a small container in a particular location, then publishing the latitude and longitude coordinates of the location on a geocaching website for other 'geocachers' to find using a GPS device (Geocaching website 2011, <http://www.geocaching.com>). In essence, it is a GPS-enabled outdoor treasure hunt. Geocaching – and our suggestion of Musical Treasure Hunt – is motivating to the users for several reasons (O'Hara 2008): It gives outdoor activity a sense of purpose, and makes exploring new places meaningful. The geocaching website keeps record of all the different caches a particular geocacher have done. Building this up, as a collection is an important driver for continued participation. Part of the value of collecting practices comes from being immersed within the social context of the geocaching community, and how the achievements are represented to others. Finding the caches can be very challenging, and it can be seen that location-based technologies provide value not

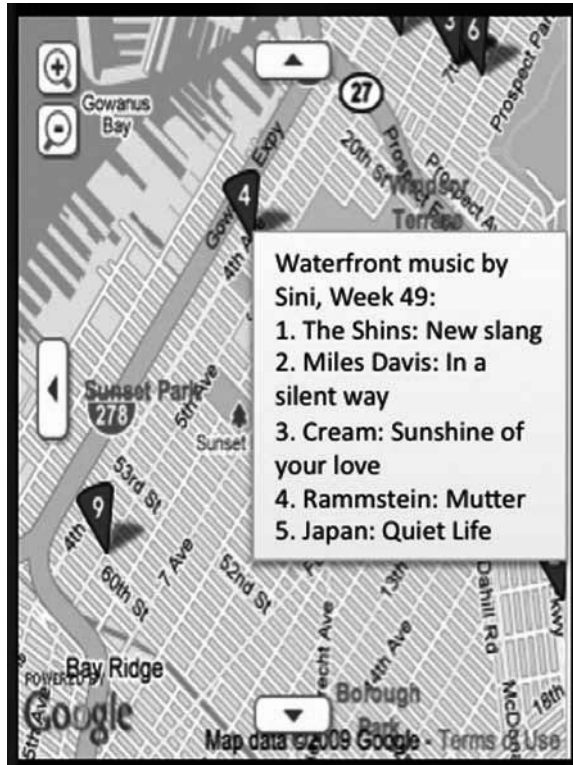


Figure 3. Example of a user-created musical hotspot with time-sensitive playlist on a mobile phone display.

simply by making it easy to get information at the right place and time, but also by making it difficult.

In Musical Treasure Hunt, users seek musical treasures marked by GPS coordinates. It is also possible to gather musical clues in different points of a musical treasure path, and add time-based competitions ('who finds first'). It can be seen as an augmented reality service, where users move around the city to reach the city. Within the domain of location-based computing, geocaching represents an interesting research topic. As a technology-enabled location-based activity, it is useful in understanding both itself and also other location-based practices. In geocaching, people participate not just through the *consumption* of location-based experiences but also through the *creation* of these experiences for others (O'Hara 2008). Musical geocaching can be used to study the ways in which people give meanings to and appropriate the location-based ubiquitous media.

### *Sounds of Helsinki*

Just as cities such as London, Atlanta and Oslo (Lee and Cunningham 2012) are trendsetters in music consumption on national and global scales, districts of a city have their own identities and social positions. Geo-cultural idiosyncrasies reflect the music listened in different areas. Using this concept, we want to study and illustrate the constantly changing musical identities of different districts and how musical memes,

e.g. new music releases, spread in urban areas. Name Sounds of Helsinki refers to the city and its districts that inspired the initial concept idea.

The music listened in different districts of the city generate playlists that change over time. Users are offered playlists and recommendations in their mobile phone while moving around the town based on, for example, the popularity of music listened in those areas or by filtering based on personal preferences. Motivations for the users include discovering new music and thereby getting joy out of very ordinary everyday life situations like commuting. This concept also allows local artists to tag their music according to the places it was created at, where the artist hails from or which locations the lyrics refer to. These pieces of information may be combined with information on past, future or ongoing live performances. Visualizations on a map application are a type of psychogeography-inspired maps in a form of web mash-ups.

### ***Reflections of the first working prototype: festival recommender***

The field trials of the first prototype, an urban music and events recommender, were conducted in August 2011 in Helsinki during urban festival called *Helsingin Juhlaviikot*. Prototype was designed for a smartphone with mobile web browser. We wanted to offer users a simple and elegant way of getting recommendations unprepared and on the move. Compared to many other recommendation services, to receive quality recommendations users does not need to train the recommender at all. Users were sent notification of a new recommendation by pop-up screen. By touching the pop-up window, user enters the actual user interface, which shows the name of the event, the address and a map automatically scaled so that the location of the user and the recommended event location are presented as points on the map. Media player was also provided, with relevant music or video link. Moreover, we provided thumbs up, thumbs down function for instantly gathering user response.

Of the 241 recommendations sent, 88% were checked out, indicating that the system was *effective in increasing awareness of available events*. Of the recommendations that were viewed, 35% were rated as good (thumbs up), 22% as poor and 43% were not rated. Although individual event recommendations were not considered particularly interesting, according to the overall satisfaction survey, users were satisfied with the service prototype and the recommendations it provided for determining which events to attend. *Temporal and spatial relevance* of the recommendations was not very important for people living in a mid-size European metropolis with relatively short distances and an efficient public transportation system. The responses also suggest that the recommendations had little impact on the *behaviour* of the participants, mainly due to the users pre-planning their daily schedule. However, in their verbal feedback, participants reported having an increased and intensified feeling of living in the flow of the city. Users felt strongly that they are part of the city life that is happening around them, even if they were not going to attend the events. The user responses also indicate that most of the recommendations were for artists who were previously unknown to the participant and for events that the participant had not heard of before. Together with the high consumption rate of additional media, the results indicate that our prototype was *effective in supporting serendipity* (Forsblom et al. 2012).

### **Conclusion**

According to our results, the first prototype was successful in providing serendipitous recommendations and adding empowerment in the participants lives in an urban context.

Empowerment translates here mostly as an added intensity of experience of living in the city's stream of events, generated by the received recommendations. The research proceeds by implementing various prototypes of research concepts under the umbrella of the SoundAbout platform, including user research and iterative design cycles where new functionalities are added, e.g. various visualizations and contextual data for producing better recommendations, and by that, novel ways of making urban everyday life richer by giving people sound, time and location-based tools.

## Note

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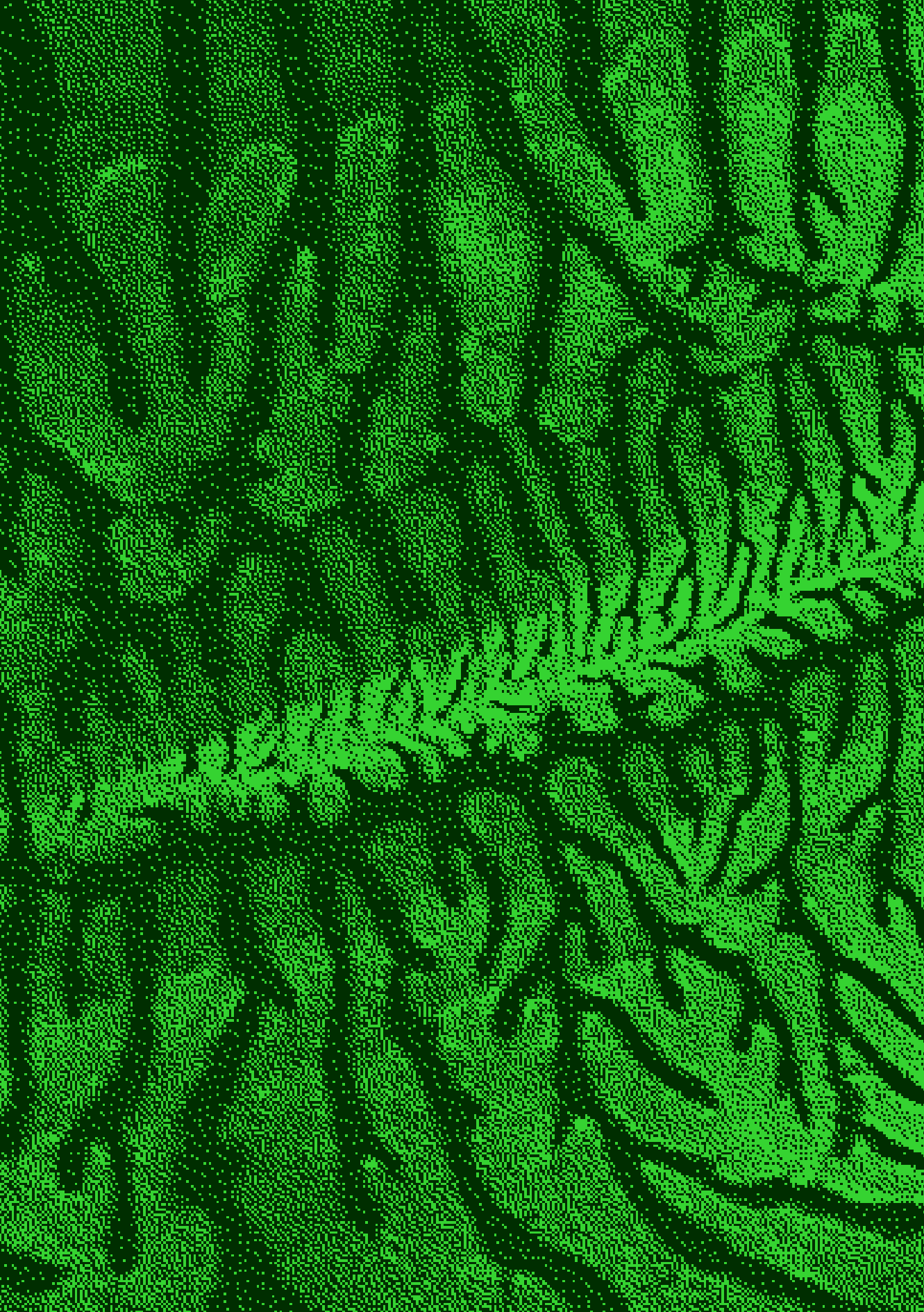
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**Article IV**  
ENRICHING USER  
EXPERIENCES WITH  
LOCATION-SENSITIVE MUSIC  
SERVICES

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## Enriching user experiences with location-sensitive music services

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### ABSTRACT

The wide adoption of mobile devices and streaming music services has paved the way for location-based music services. However, there has not yet been any commercial breakthrough. We designed OUTMedia, a location-sensitive music discovery application with unique features, to explore rewarding user interactions. This article reports the design efforts and a field study of the functional prototype. We utilised user interviews, log data and the ResQue instrument to study use and user experience of the prototype. All measures found the overall concept feasible and the use of the application resulted in serendipitous experiences of music and places. Our findings call for service designers to support the interplay between media and places in personal meaning-making processes, to enrich urban cultural experiences with user-created information layers that accumulate over time. The design implications can be used to support serendipitous music experiences through the interplay between places and media in future content discovery services.

### ARTICLE HISTORY

Received 28 November 2014  
Accepted 18 September 2015

### KEYWORDS

Music discovery; location-based services; urban computing; serendipity; music interaction

## Introduction

Various music recommendation approaches have been introduced in the last decade, typically recommending other users or music tracks. This has been necessary to navigate the quickly expanding space of digital music catalogues that offer tens of millions of items. Recently, some applications have expanded this two-dimensional (2D) recommendation approach to include contextual factors, information that describes a user's situation in some way. Since music content is highly portable, adding a user's context as a dimension of recommendations is increasingly important. Contextual information that has been used for music recommendation in research prototypes includes factors such as location, time, mood and various biosignals such as heartbeat or skin conductivity. While desktop music applications have involved personalisation and filtering options, mobile applications have mainly used location information (Adomavicius and Tuzhilin 2005; Baumann et al. 2007; Braunhofer, Kaminskis, and Ricci 2011; Liikkanen 2012; North, Hargreaves, and Hargreaves 2004; Nurmi and Bhattacharya 2008; Reddy and Mascia 2006).

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A subset of the results was presented at the Symbiotic 2014 workshop in Helsinki, Finland

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Location-aware technologies open new opportunities for offering novel experiences and empowerment in urban settings (Paay and Kjeldskov 2008; Paay et al. 2009). Location-based services also have unprecedented social and behavioural implications that can be exploited in their design (Michael and Michael 2011). There are few studies that explicitly describe their stance on the relationship between music and location (e.g. Bull 2008; Hakansson et al. 2007; Seeburger, Foth, and Tjondronegoro 2012). Bull (2008) has studied the sociology of individual music listening in public space, discovering that one of the main functions of listening to recorded music through headphones is creating ‘a private auditory bubble’ within a public space such as a metro train. Bull’s main theoretical claim is that people use music to manage, control and even temporarily conquer public spaces by creating their own personal places or ‘non-places’ within them. We use this as an underlying theoretical assumption of our work: through music, people will create their own meaningful places (Nurmi and Bhattacharya 2008) within public space, if they are given the media-related tools to do so. Due to the lack of research on the topic, the relationship between music and location is by no means an agreed one and other stances include the view that through mobile media applications, music can be used as an incentive to begin social interaction with collocated strangers (Hakansson et al. 2007; Seeburger, Foth, and Tjondronegoro 2012).

Serendipity, a positive encounter by chance, is one potential experience that location-aware services may provide (Celma 2010). Since music can be connected to places in an arbitrary fashion, location-aware music services have great potential for providing serendipitous encounters with media content. Serendipity has been the goal of several music recommendation systems (Zhang et al. 2012) and some studies focus on music listening patterns (Leong, Vetere, and Howard 2012), but without consideration of the mediating role of physical location in the experience. Services that use location as a context-sensitive factor are especially appropriate for recommending live music because live performances unavoidably have a connection to the physical environment in which they take place.

Given the evident motivation for and opportunities in location-based music, we may wonder why it has not yet gained popularity. As we review the field in the following, we argue that the lack of success is because the current services do not support new kinds of user experiences (UX) and are therefore not desirable enough to users. In this paper, we attempt to address this deficiency and explore the enabling experiential features of location-based music.

Through an earlier map-based mobile prototype, we studied the feasibility of urban context-aware music and event recommendations (Forsblom et al. 2012). In the current study, we have expanded our approach to investigate the richer associations of music and place with the addition of social computing. Because there were no location-based music services with enough users or content available, we were required to simulate the (user-created) content. We decided to do this in a custom-built research application using an augmented reality (AR) interface that links music content to a specific place. Unlike traditional 2D maps, AR UIs enable a direct connection and physicality with a user’s immediate surroundings. AR interfaces are natively *location sensitive*: they commonly deploy a user’s immediate physical location for the interaction (see Figure 1). As further motivation, our review shows that current context-aware music apps do not use AR, but on the other hand, urban AR apps do not support music discovery. Our application connects music to places freely chosen and annotated by the users.

This article reports the field study of a location-sensitive media discovery application. We developed a functional prototype of a location-based music service, OUTMedia, through a



**Figure 1.** Participant of the field study scanning his surroundings to find interesting AR objects.

research-through-design approach (Fällman 2008). We provided simulated user data and music objects (in an applied Wizard-of-Oz fashion) to study UX and understand potential design success factors. We were interested to learn how active music listeners experienced the service prototype in terms of serendipity, overall UX and engagement. This combination of research goals and novel technology makes our contribution unique in the research field. Our results indicate that the main design goals were fulfilled, and our 18 participants maintained sustained attention to the application and enjoyed freely discovering new music, as measured by log and interview data, user survey and the adapted ResQue instrument (Pu and Chen 2010). Findings imply critical design features: the interviews show that it is important to support open meaning-making, time-based discovery of media and place and location sensitivity.

## **Background and related work**

The most relevant work to our study can be found in the fields of contextual music recommendations and location-based services. Since the development of new mobile AR interactions is not the main focus of our study, there are many related commercial and research systems; we will summarise these services and prototypes (both music and AR apps) in a table and discuss them briefly.

### ***Music discovery and urban AR***

Traditional 2D music recommendation ignores the essential contextual dimension of music listening (Adomavicius and Tuzhilin 2005). Music choices depend strongly on a user's situation (Levitin 2007; North, Hargreaves, and Hargreaves 2004). Modern mobile phones and tablets have rich sensing capabilities, leading researchers to employ contextual information in some recent mobile music recommenders (Braunhofer, Kaminskas, and Ricci 2011; Wang, Rosenblum, and Wang 2012). The contextual factors with the most potential to be utilised for music discovery include location, time, function (e.g. sports and reading), social setting and mood. All of the above may influence a user's music preferences at a particular moment (Lehtiniemi 2008; Nurmi and Bhattacharya 2008). In a recent article, Åman and Liikkanen (2013) discuss several location-based music service concepts, which are still mostly unrealised.

Mobile AR applications typically add a new digital layer or multiple layers to the physical world, mediated by the mobile device's camera. These applications are expected to gradually become part of everyday computing (Olsson and Salo 2011). With AR, local searching no longer means looking down at a screen for information, but also looking out at the world in a more natural way (Olsson and Väänänen-Vainio-Mattila 2011). Currently, AR media is slowly approaching mainstream computing through products such as Google Glass.

### **Review of the existing applications**

We reviewed 22 relevant applications, which we have summarised in Table 1. There are several research and commercial applications for location-based music discovery, but none that would include both curated, user-created and automatically generated music content *in* an application that allows content to be accessed only when near the actual location: in a location-*sensitive* way (in our case AR). Examples of music discovery apps in the consumer market include Shazam ([www.shazam.com](http://www.shazam.com)), Blicko ([www.blicko.com](http://www.blicko.com)), Spotisquare ([www.spotisquare.com](http://www.spotisquare.com)), Tunaspot ([www.tunaspot.com](http://www.tunaspot.com)) and Soundtracking ([www.soundtracking.com](http://www.soundtracking.com)). These are usually mashups of two or three key functionalities, combining, for example, a music service and location service such as Spotisquare, which allows users to attach Spotify playlists to Foursquare locations. Blicko is a social jukebox web application that uses location data to show the nearest 'stations', playlists that are attached to places such as gyms, bars or live venues. Shazam is currently the most popular of these services. It scans the music currently playing, using the mobile device's microphone, to find the track's basic information. It can also produce lists for the most played tracks in different neighbourhoods.

Some research prototypes have explored the connection of music to location more thoroughly. Capital music is a research system that allows song selections to be shared between collocated strangers in public places (Seeburger, Foth, and Tjondronegoro 2012). The actual music content is not shared, only track information. BlueTunA (Baumann et al. 2007), Push!Music (Hakansson et al. 2007) and The Compass (Tanaka, Valadon, and Berger 2007) allow music discovery by displaying the music that nearby users have in their devices, but do not allow music to be attached to places. Lifetrak is a mobile music recommender, generating playlists using device-based music library (Reddy and Mascia 2006). It matches the offered music stream with the current context of the user (location, time, weather and activity information), but does not allow music attached to places. Similarly, in multi-contextual music recommenders by Wang, Rosenblum, and Wang (2012) and Lehtiniemi (2008), users do not have the ability to create place–music combinations.

Ankolekar, Sandholm, and Yu (2013) studied the musical 'icons' compiled from popular music, called musicons. They investigated how musicons can function as cues and emotionally engage users in discovering their surroundings and related points-of-interest (POIs) serendipitously in unfamiliar places. They discovered that musicons created a much more pleasant and engaging user experience for POI identification and discovery, when compared to the other offered visual, speech or auditory icons. Braunhofer, Kaminskis, and Ricci (2011) studied the matching of music to POIs in a contextual mobile travel guide. They discovered that users liked the music tracks more if they were presented in the context of the visit compared to only listening to them. In a study of an outdoor gaming prototype for music discovery, users could conquer physical areas in a map view by attaching songs to them (Lehtiniemi and Ojala 2012). Storyplace.me (Bentley and Basapur 2012) allows the public



**Table 1.** Properties of the reviewed location-aware applications.

1. Name of service or publication	2. Type	3. Loc. data	4. Loc. sens.	5. AR	6. User annot.	7. Free placem	8. Music first	9. Music access	10. Discovery	11. SoMe
OUTMedia	R	X	X	X	X	X	X	X	X	X
LifeTrak	R	X	-	-	X	-	X	X	X	X
BlueTunA	R	-	X	-	X	-	X	-	X	X
PushMusic	R	-	X	-	-	-	X	X	X	X
The Compass	R	X	X	-	-	-	X	X	X	X
SuperMusic	R	X	-	-	-	-	X	X	X	X
MyTerritory	R	X	-	-	-	X	X	-	X	-
StoryPlace.me	R	X	-	-	X	X	-	X	X	X
Wang et al.	R	-	X	-	-	-	X	X	X	-
Braunhofer et al.	R	-	-	-	-	-	X	X	X	-
Capital Music	R	X	X	-	-	-	X	X	X	X
Sounds of Helsinki	R	X	-	-	-	-	X	X	X	X
Musicons	R	X	X	-	-	-	-	X	X	-
BOTTARI	R	X	X	X	-	-	-	-	-	X
Tunaspot	C	X	-	-	X	X	X	X	X	X
Shazam	C	-	X	-	-	-	X	-	X	X
Blicko	C	X	X	-	-	X	X	X	X	X
Spotify	C	X	-	-	X	X	X	X	X	X
Soundtracking	C	X	-	-	X	-	X	-	X	X
Layar	C	X	X	X	X	X	-	-	-	X
Wikitude	C	X	X	X	X	X	-	-	-	X
Tagwhat	C	X	X	X	X	X	-	-	-	X
Mixare	C	X	X	X	X	X	-	-	-	X

Notes: 'X' indicates support for the property. Columns: 2. (R)esearch or (C)ommercial app.; 3. Uses location data; 4. Location sensitive; 5. AR interface; 6. User annotates the content; 7. Free placement of content; 8. Music is the main content; 9. Music content accessible; 10. Music discovery; and 11. Includes social media features.

sharing of audio and video stories, and Sounds of Helsinki (Forsblom et al. 2012) recommends cultural events using time and user location, but none of these is location sensitive, as the content can be accessed when not on location.

As the development of new mobile AR interactions is not the main focus of our study, we will present only briefly some of the research concepts and commercial systems that we have used for inspiration in the design of an urban AR app.

Recent smartphone applications allow the viewing of Wikipedia and social media types of content in an AR view (Olsson and Salo 2011). Following the first applications, such as Layar Reality Browser ([www.layar.com](http://www.layar.com)), several other examples emerged. The Wikitude World Browser ([www.wikitude.com](http://www.wikitude.com)) is an AR browser based on Wikipedia and Qype content. Mixare ([www.mixare.org](http://www.mixare.org)) shows Wikipedia, Twitter and Buzz entries around a user in the camera view (AR), map view or in a list. Tagwhat ([tagwhat.com](http://tagwhat.com)) is a location browser that lets members explore the world and interact with friends in an AR world. Balduini et al. (2012) present BOTTARI, an AR application that offers personalised and localised recommendations for POIs based on the temporally weighted opinions of the social media community. None of the AR applications focuses on music discovery, however.

Table 1 shows that OUTMedia is the only app that (a) utilises context sensitivity (through an AR interface), (b) offers music as its main content type and (c) lets users create the located content freely with their own annotations. Of the reviewed research and commercial applications, Tunaspot resembles OUTMedia in that it offers user-created location-aware music–place combinations, but it is not context sensitive in the manner we use the concept. Context sensitivity, or in our case, location sensitivity, means that the content *can only be accessed* in close proximity to the location. Tunaspot adopts a 2D map UI to present playlists that can be viewed online, without having to be at the location where the music has been attached.

## Design and prototype

OUTMedia presents a second phase in a longer design and research process. The first prototype was implemented using a 2D map user interface for location-aware music and events discovery. The current prototype is an expansion in order to study the user perception of an AR UI. As our main focus was not to come up with novel AR interactions, however, we applied tested and proven design features found in established commercial applications such as Layar and Wikitude.

The concept of the service was developed in a series of iterative workshops with early adopters of mobile music services. The concept of a location-sensitive music service included not only the idea that music objects have location, but that users can also create objects and provide their own annotations for music–place combinations for others to discover, comment and share. We also wanted to study the user perception of automatically created, location-sensitive playlists. In the OUTMedia app, users scan their surroundings in order to find interesting AR objects, then tap the object to open it, revealing a media player accompanied with varying text annotations.

The novelty of OUTMedia lies in the location-sensitive music content that is attached to places according to a variety of motivations. The system includes user-created, promotional and automatically generated content and user-created annotations *together* with an AR user interface. We tested our concept by building a prototype that realised some features of the concept.

## AR objects and POIs

The focus of the interaction centred on the AR objects, which were connected to geographical POIs. Each AR object had seven properties: *POI, category, music clip, time stamp, title, text annotation* and a *user name tag* (Figure 2).

In a workshop, users who were familiar with the district were asked to mark on the map (a) where they spend time regularly, (b) where they would leave music and (c) why would they do so. Most of the POI locations were gathered this way; however, in the final locations, all textual information and the music were selected and created by the researchers, resulting in an adapted Wizard-of-Oz study (Klemmer et al. 2000).

In the AR view of the user interface, four kinds of AR objects were offered: user-created content (UCC), music events (live gigs and DJ events) and promotional (food or drink). These were marked with different colours and icons, shown in Figure 3. OUTMedia also had a ‘Soundtrack of a Place’ feature, which simulated automatically generated playlists based on four of the most recently played tracks in the user’s vicinity.

The text annotations in the different categories were semantically distinct and followed a tweet-like limitation to a maximum 140 characters. For music events and promotions, annotations were knowledge based, describing the performer or detailing the promotion. In the soundtrack, the annotation contained the playlist’s track information.

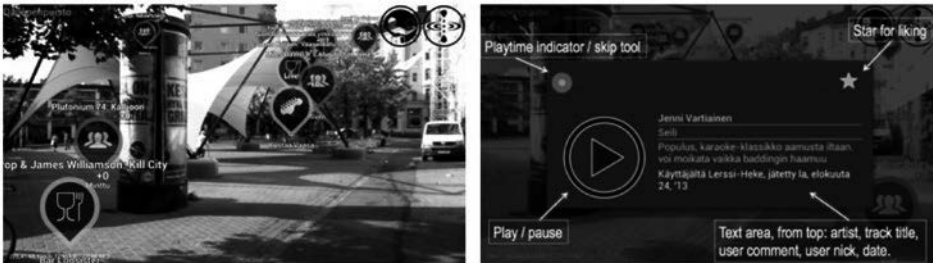


Figure 2. UI views: AR view (left) and player view (right).



Figure 3. OUTMedia UI symbols (from top left: UCC, Live Gig, DJ, Promo, Friend filter and Soundtrack of a Place).

User-created annotations included two types: *knowledgebased* and *arbitrary* (cf. tag-based relationships in Braunhofer, Kaminskas, and Ricci (2011)). In knowledge-based objects, there was a factual relationship between a place, music and annotation. For example, a ‘punks with their dogs here’ annotation was made for a local punk song at a POI usually occupied by punks. Arbitrary relationships simulated user activity by linking music, a place and an annotation by what feels right or wrong (ironic, controversial, etc.). For example, ‘this park commemorates WWII veterans’ for a Frank Zappa tune with pacifist lyrics.

## User interface

Users browsed their surroundings using the AR view (Figure 2), where objects were presented floating on the screen in the camera view. By tapping an object, the player view opened. The player view presented users with an audio player, which included a timeline of the music track, play/pause button and a ‘Favourite’ button. Time stamp, annotation and the user name were also shown (Figure 2). The AR view also had two controls on the upper right corner, ‘Friend Filter’ and ‘Soundtrack of the Place’ and a play and pause button on the lower right corner. The Friend filter function mimicked social cues and filtered visible objects based on the real interactions of the user’s friend-pair. Activating the filter limited the count of visible objects to eight. These were chosen first on the basis of the items the friend liked (using a star symbol for the Favourite feature, Figure 2), then the items the friend played and finally the items the friend opened in the player.

## Field study media content

To simulate the promotional, automated and UCC of a real-life commercial application, 111 AR objects were created altogether. AR objects were attached to geographical POIs located evenly across four parks, resulting in an average of 28 objects per park. To represent the realistic divide of a real-world service, 60% of the AR objects belonged to the UCC category, the rest belonging to the other categories. The district of the city that included four parks is known for its many live venues, bars and popular summertime outdoor hangouts. Researchers gained a thorough knowledge of the district so that the places and the music attached to them could be precisely targeted to the user segment involved in the study. The application was otherwise mostly functional, but user movement was limited to the four predefined clusters where the AR objects were visible. We used a web application to manage the POIs and AR objects, which provided batch output for an Android application assembly phase. A pre-assembled collection of data embedded in the application was needed to guarantee a consistent UX.

## Implementation

The application was developed for the Android platform and the experiments were conducted on Samsung S3 devices. This device has a 4.8-inch screen and includes an 8-MP camera that provides the image for the AR application. Determining AR object visibility is a three-stage decision process: (1) Does the object belong within the field of view of the camera? (2) Is the object part of the cluster in which the user is located, i.e. Parks 1–4 (determined by the distance to the cluster’s location)? (3) Is the Friend filter on or off?

The application relies on the smartphone's accelerometer and compass to determine the orientation of the camera of the device. It determines the physical field of view for the camera of the device and uses this information to calculate the visible objects. Only the compass angle is taken into account when determining visibility and the objects are placed on an imaginary Cartesian plane. The placement algorithm in the application is straightforward. On the X-axis, the location of the object is determined from its deviance from the camera-pointed angle; on the Y-axis, by its distance from the user compared with the other visible objects. The nearest object is drawn at the bottom of the screen and the other objects are behind it and on the Y-axis on top of it. To prevent the drawn items from moving too quickly for the user and to provide an illusion that they are moving, the location of a given item is determined by linearly interpolating its location, given its location in the previous frame and its ideal location calculated by the placement algorithm.

## Method

We organised a field study, as it is essential to evaluate mobile service prototypes in real-life settings, not least in our case, where the limited application functionality did not allow for handing it out for private use. There are several advantages of undertaking field research with mobile applications (Goodman, Brewster, and Gray 2004; Oulasvirta 2008); however, real-life settings also pose disadvantages including traffic, weather, outsiders and other noise sources.

The main goal of the field study was to evaluate UX with the service. The persuasiveness of different kinds of AR objects in providing music recommendations was a major object of investigation. Our main research questions were: *Does the system engage users in music interaction? Does it provide serendipitous music recommendations? Does it inspire user experience of the locations through music content?* To answer the questions, we undertook interviews, used structured surveys and gathered log data, as well as recorded the verbal comments of users during the experiment.

## Participants

Eighteen participants were recruited altogether, using snowballing via social media. We required that participants actively try to find interesting new music for listening to through mobile devices and that they were familiar with smartphones. We also ensured that participants regularly spent time in the city's parks. Participants were 23–41 years of age, 10 female and 8 male. In the recruitment phase, the first nine participants were asked to name a friend who fulfilled similar criteria for the testing of the social features of the application (Friend filter), resulting in nine pairs of participants. All were familiar with the district of the experiment and its publicly known sites and locations.

## Experiment design

All users were free to use the app in the four parks. One quasi-experimental manipulation was also administered. In two of the four parks, half of the users were urged to use the *Friend filter*, which allowed them to see only those eight AR objects that their friend-pair had liked, played or opened. If the friend had liked, played or opened more than eight objects, they were filtered in the order of interaction depth: like over play or/and play over open.

## Experiment procedure

The study started with a pre-experiment briefing, where users were informed that they could listen to the tracks for as long as they liked, but that it was advisable to spend around 15 min in one park. They were also told that the route through the four parks would take approximately one and a half hours and that immediately after its completion, a questionnaire and an interview would be administered. Upon inquiry, users were told that the POIs were gathered from users like themselves using a printed map. Users were informed that the radius for visible POIs was around 250 m, so they were in eyesight or within a short walking distance. Users were told that they were able to 'Favourite' the POIs they found interesting using the UI's 'star feature'. After presenting orientation material, users were given the Android smartphone with the application and wireless Bluetooth headphones. One hundred eleven AR objects were planted in four geographical clusters (parks) within walking distance (400 m) from each other, forming an almost two-kilometre long route. The experiment started at the southernmost park with the guidance of the researchers and proceeded to the northernmost, where the interviews took place and the survey was completed. In each park, participants were free to use the application to scan their surroundings for AR objects, listen to the songs and interact with the app.

## User evaluation

A combination of methods was used to evaluate user experience. These included analyses of log data, a questionnaire and interviews. The application logged all user interactions and also system statuses on regular basis while there was no interaction. All user interactions were recorded sequentially with a new timestamp applied every second. The log data were pre-processed using Microsoft Excel and analysed with SPSS.

After the experiment, users completed a three-part questionnaire. The first part was adapted by reducing the original ResQue questionnaire's 60 claims to 28 claims relevant to our study. The excluded claims were intended to measure features that would be irrelevant for our prototype, and were thus omitted in the design process. For example, buying the music content as downloadable files was not supported in our system. Pu and Chen (2010) recommend reducing the number of claims to suit the current study, and therefore we believe that our adaptation does not threaten the validity of the ResQue instrument.

The claims included in the survey belong to four *constructs* (Pu and Chen 2010). Our questionnaire included 17 claims about (1) *User-Perceived Qualities*, 6 claims about (2) *User Beliefs*, 1 claim about (3) *User Attitudes* and 4 claims about (4) *Behavioural Intentions*. Claims were operationalised from constructs such as user attitudes (e.g. 'Overall, I am satisfied with the recommended items') or behavioural intentions (e.g. 'If a recommender such as this exists, I will use it to find products to buy'). The ResQue instrument, standing for *Recommender systems' Quality of user experience*, is designed to measure the entire user experience of recommender systems, including user-perceived qualities and satisfaction levels (ibid.). Participants were also interviewed after the experiment regarding 12 themes that explored the acceptability and UX of the concept and application, the perception of various media types within the objects and the quality and contents of the POIs.

## Findings

This section describes our results, starting with the experiential features. We will return to the design implications in the discussion section. We begin by considering the social and practical benefits our participants perceived in the application.

### ***Experiences: meaning-making in space***

In the interview data, we discovered three important themes through grounded theory analysis (Birks and Mills 2011): *open meaning-making*, *embodied music interaction* and *place and time*.

### ***Open meaning-making through interplay between location and media types***

According to interview data, the meaning- and sense-making of objects take place when a text, place or music triggers a specific meaning from many possible meanings available (obviously not all known by researchers or participants). Sometimes, the triggering element was a user annotation; in other cases, it was the music–place combination. Information from all three elements was important.

The concept of ‘open meaning-making’ is formed from the observations of the qualitative user data and by this we refer to the way semiotics and cultural studies understand meaning-making process: it is actively constructed both through subjective and social processes. In human communication, meaning is never fixed. Neither things themselves nor the individual users of language can fix the meanings of a given language. Things do not *mean*: meaning is constructed in social practices, in the use of representational systems: concepts and signs (Hall 1997). In practice, this means that the meanings of things change all the time and there is always room for reinterpretation. For example, the word ‘cool’ gained its meaning through a social process, where the use by older generations of the word ‘hot’ became boring and unfashionable for the younger generation who started using ‘cool’ to describe things that their parents had described with the word ‘hot’. In other words, ‘cool’ gained the meaning ‘hot’ in a social practice of making a generational distinction. In this study, the concept ‘open meaning-making’ means the varying interpretations of the combinations of music, place and text annotations that were negotiated by the users.

The meaning-making processes adopted by our users remind us of *anchorage*, a term coined by Roland Barthes in the context of semiotic analysis of newspaper photos with captions and advertisements with text elements (Barthes 1977). The addition of text is a powerful method of modifying or fixing the meaning of an image. For example, in a news photo depicting a clash between a crowd of people and police, a newspaper editor can fix or ‘anchor’ meanings by choosing various captions: ‘freedom fighters rising against tyranny’ or ‘vandals attacking the police’ (Fiske 1990). Captions with a news photograph or the text in an advertisement often determine exactly how the picture should be interpreted, thus anchoring certain meanings of the many that are offered by a picture.

In our case, we found that each of the elements of an AR object, text annotation, music or place, can anchor meanings that vary greatly depending on the user, their personal history, values, knowledge of the place, music, the text and so on. The interpretations were often very personal and allowed for serendipitous discoveries.

First I checked out the songs, then read the comments, they were a nice extra. I couldn't help laughing at some of the comments, they matched the place so well. (Participant 12, female) There were songs that I just had to click to see why somebody had left it exactly here. (Participant 6, female)

The easiest (and most obvious) way of making sense of the combination was when textual information had a factual relationship to music or a place. For example, Bach's Toccata and Fugue placed at a churchyard is an example of a factual, knowledge-based relationship between the elements. Some of the music–text–place combinations were purposely designed with a totally arbitrary connection or a dissonant connection. These would often result in a baffled or surprised reaction. For example, one user commented, 'I wonder what kind of food they sell there' on Johnny Cash's song *Hurt*, placed at a late-night food stall.

Several users commented that they most liked the user-created objects because the annotations were not obvious. The combinations of the three elements gave unique interpretations of music or place and provided new associations for them, often resulting in serendipitous discoveries.

### ***Location-sensitive media as 'the extensions and restrictions of man'***

One of the most important features of online media has been its ability to overcome the restrictions of space and time. Our user's comment about *not* getting everything online, beforehand and from a distance, but *content available only when on location*, sees the restrictions of space and time as positive. This reversal can be observed through media theorist Marshall McLuhan's (1964) notion of 'media as extensions of man'. McLuhan sees media (and any technology) as extensions of the human body and its senses. For example, telephony is an extension of hearing, while a modern day example would be the Internet, extending human senses in many ways. Our modification of the concept 'media as extensions of man' to 'media as extensions of *and* restrictions to man' is fruitful in the context of our work in two ways: as a concept derived from the qualitative user data for explaining the user responses to a context-sensitive user interface and providing a design implication for the designers of future systems. We will return to the latter in the discussion and conclusions section.

Our modification of McLuhan's concept leads to an interesting juxtaposition of location-sensitive media (in our case AR) as an extension of and, at the same time, a restriction on humans. Users felt that when content was available only on location, the opportunities for serendipitous discoveries were greater compared to content that could be examined before going to the location.

Nowadays, everything is so digital; people just get immersed in their smartphones. This happens outdoors, you have to be physically in a certain location, to get the content. (Participant 17, female)

Another AR-related finding was that our participants would use this kind of application for the basic mobile phone function of constantly determining what is going on 'right now (online)'. The added twist in our application is that it enables discovery of not only what's going on right now, but also 'right now, right *here*' due to AR's location-sensitive quality.



## ***Experiencing place through time***

Users felt that by accessing the objects, they could experience what had happened at a location earlier. Like a geographical social media timeline, accessing music–text–place combinations that have accumulated in certain places enriches UX of the place. This finding is in line with Paay and Kjeldskov's (2008) findings about the location-aware application prototype they studied in an urban setting: experiencing a place through time enriched the user experience through the (Gestalt theory's) principle of *continuity*. According to the interview data, applications similar to ours clearly have potential that could result in a city with a virtual (and, with AR, also virtual-physical) multi-layered dimension of cultural content that changes over time.

With these objects, one can experience the place's mentality and part of its cultural history, also those who don't know the district. (Participant 11, male)

Accumulation of the soundtracks of places by people's activity is a good idea. (Participant 16, male)

## **Opinions**

### ***The forms of serendipity***

We combined three data sources to understand *serendipity*: (1) five claims from the ResQue questionnaire concerning the *goodness* and *novelty* of the music in POIs, (2) the questionnaire's third-part question 'Did it help to find new, interesting music?' and (3) interview responses to 'Why did you choose to Favourite an object?'

In the first data source, all five measures were, on average, in agreement (mode 5 out of 5). In the second source, averages summed for all measures were fairly high (mode 4 out of 5). In the majority of interview responses (37%, 43 mentions), users stated that they liked the POIs because of their serendipity (new, good music) or *pseudo-serendipity* (old favourites newly discovered).

From the interviews, we picked 43 responses in the theme 'Why did you choose to like POIs?' These fell into three categories: (1) *Good music* (65%): (a) good (personal preferences); (b) familiar, good track (preferences and familiarity); (c) pseudo-serendipity (forgotten good music); or (d) real serendipity (new good music). In 37% of the responses, users said that they liked the POI due to serendipity or pseudo-serendipity. The second category included *Good combination of music, a place or annotation* (28%). The third was *Sharing* (e.g. 7%, 'I liked to share good music for others to find').

### ***Opinions on the service***

Most of the users (two-thirds) had an unreservedly positive response to the question of how they felt about music discovery by scanning one's surroundings. In all, 28% responded positively and added a remark. One user did not like it because she felt that scanning one's surroundings, and specifically other people, through a smartphone camera triggered privacy issues. Those that responded positively, but with a remark, mostly commented on usability issues (described below).

Over a third (39%) of the users had opinions about the contents of the user-created annotations. For instance, when scanning in AR mode, users often became curious and wanted to check the annotations section for the real reason someone left a particular piece of music in

that place. Others felt that annotations, perceived as comments, were likable because they could sympathise with the other user in terms of lifestyle, humour or the creative associations constructed about a place, time, music and user annotation. Users almost unanimously felt (89%) that the POIs were realistic and that music was attached to the places in a meaningful way. Only two users disagreed with this.

### ***Desired features***

Half (9) the participants expressed a wish that OUTMedia would include more *social media* features. They specifically wished to leave their own comments and see them presented on a Facebook-style timeline. It was also noted that the meaningfulness of comments depends on social proximity, especially when commenting on or reading comments from close friends.

When asked if they would like to scan their surroundings this way to discover other things, 67% of the users felt that music together with user comments or curated information was enough for the experience. Some users suggested that photos or videos might be too sense-consuming in an outdoor setting, although others felt that it could result in an improved experience.

### **Behaviour and usability**

UX and opinions are based on their exposure to the experiment. To understand this foundation, we can look at the behaviour through the log data of 18 users. On average, user sessions took 1 h 25 min, with considerable variation between subjects (S.D. = 37 min). Music browsing was extensively utilised. On average, each user browsed through 56 POI items (S.D. = 22 items; opening the player window), almost exactly 50% of all available POIs. They started listening to 35 tracks (S.D. = 12.3 tracks). This indicates that over two-thirds (67.1%) of the opened POIs were also listened to. Users also interacted with the player, marking on average 19 tracks (S.D. = 9 tracks) with a star and removing one 'Favourite' per session ( $M = 0.83$ ; S.D. = 0.86).

### ***Attractiveness of POIs***

The most played and liked POI category was 'Soundtrack of a Place'. The soundtracks differed from other categories in that they were not moving objects like other POIs and had their own symbol in the upper right corner of the UI (Figures 2 and 3). Users also played back soundtracks for longer than other tracks (1:12 vs. 0:51,  $F(1, 633) = 5.622$ ,  $p = 0.018$ ). This is related to the fact that soundtracks consisted of multiple tracks and the user had the additional control element 'Skip' available. This button was used on average four times per session, although not all users chose to wind forwards ( $M = 4.1$ ; S.D. = 4.8). There were no significant differences between other types of POI categories.

Of the other categories, survey data show that users liked UCC, Live Gigs and DJ objects most, followed by the soundtracks and promotional objects. The live gigs and DJ categories had timely information about what was happening within walking distance, which explains their high rank among categories. Survey data also show that user-created POIs were the most liked; however, log data show that UCC POIs were played and liked as much as all categories on average. Interestingly, the interviews revealed that in the case of UCC, users found that even when the music was bad, if the comment was interesting, they chose to

like the POI and vice versa. Log data show that in 10% of the most played ( $N = 12$ ) and most liked POIs ( $N = 13$ ), there were no differences between categories. Over half (58%) the most played tracks were also present in the most liked group.

**Influence of social information**

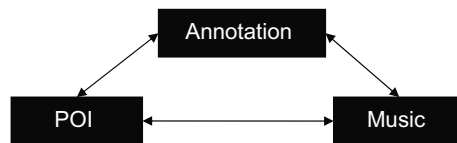
Enabling the Friend filter influenced interactions with the application only slightly, mostly in terms of the amount of attention paid to POIs. On average, POIs were viewed for 14.5 s with the filter, but for 20.0 s without it. The difference was statistically significant, despite the remarkable variability in behaviour ( $T$ -test not assuming equal variances,  $t(135.304) = 2.758, p = 0.007$ ). This left less time for users to perform other activities, such as liking the POI.

**Formal usability and UX assessment**

An adapted ResQue evaluation instrument was used to assess usability and other aspects of user experience (see Figure 4). The mean scores for the constructs are shown in Table 2. The overall average is around four, indicating a high level of positive agreement with all the claims. Only interface adequacy received a slightly lower average score, probably reflecting the issues that emerged in the interviews (object occlusion and the ‘Back’ feature).

A common usability-related comment in the interviews was the need for a generic ‘Back’ feature in the AR view. Users felt that they would need this feature in order to go back to the player view to like the currently listened song when already back in the AR view looking for new interesting objects.

The most common feedback about usability from the interviews and the verbal comments during the sessions concerned the AR objects that were located the furthest away. Because they were the smallest and often overlapping (occluding) with other objects, half the users



**Figure 4.** Place, user annotations and music all work actively together in constructing location-sensitive experiences.

**Table 2.** The mean scores for the ResQue evaluation instrument constructs.

ResQue constructs	M	S.D.
1. User perceived qualities	3.95	1.01
1.a) Recommended item quality	4.06	0.95
Relevance	4.36	0.8
Diversity	4.13	0.93
Novelty	4	0.95
Serendipity	4.08	0.91
1.b) interface adequacy	3.58	1.11
2. Ease of use and usefulness	4.3	0.9
3. User attitudes	4.06	0.94
4. Behavioural intentions	4.21	1.13

found that it was sometimes hard to hit the right object. In the design phase, we decided to scale these so that even the smallest could be hit easily, but it seems that the scaling and the movement of the objects could be further optimised. Usually, the complaints were made immediately after the start of the session and users quickly got the idea of the application. Finally, we wanted to ensure that the users had acknowledged the category allocations we thought important. In the questionnaire, users were asked to identify the six symbols of the different object categories. Symbol recognition produced 94% ( $N = 18$ ) right answers. We conclude that UI symbols were easy to remember and conveyed the intended meanings.

## Discussion and conclusions

We have presented an evaluation of a location-based music discovery service, OUTMedia. Through the user study, we found that it fulfilled our main design goals: supporting serendipitous music discovery and engaging users in music interaction (Liikkanen 2012). We found that use of the application resulted in new ways of experiencing time, places and various media content.

Reflecting our underlying theoretical assumption about people using music to create their own personal places within public space, our user data show that music can not only take people somewhere else (the created virtual place or 'non-place') but also enriches the experience of places where it is attached. Themes presented in the findings and the design implications presented in the following paragraphs show that user management, or occupying the public space through a music-place-annotation combination, does not occur only when creating a new place (or 'non-place') within a public space, but also by giving new meanings to a place and also to the music, in the interplay of all three elements. The basic strategy for making a location-aware music experience more personal mainly involves individual meaning-making and associative processes that do not necessarily centre around the location or personal meaningful place since not only the location, but each element of the music-location-annotation combination can work as a key associative element.

### ***Supporting open meaning-making through interplay between location and media types***

Designs that support a user's own content creation, interpretation and reflections have already proven successful in many social media services. According to some of our users, photos or videos could bring added value by making the media experience richer, but other users felt that music and annotations were more than enough for creating associations with the place.

Several participants preferred user-created objects because they had arbitrary, user-decided relationships between music, text and place, and thus allowed more open meaning-making. We encourage designers to include features that allow open sense- and meaning-making in their applications. These include a text field for user-created annotations, social media timeline features (as in Facebook), sharing features, the possibility to freely link any media content with places and with other people and free tagging of media content in order to achieve a richer variety of potential meanings, and thus more enriching UX.

### ***Location-sensitive media as 'extensions and restrictions of man'***

Location sensitivity can make a moment of discovery more unique and surprising since the content cannot be examined beforehand. While the application itself is an extension of humans, by enabling the creation of place–music–text combinations, we see content accessible only when on location as a *positive restriction*, a design principle that can be used in designing novel contextual music experiences. Another example of a positively restrictive design solution would be to let the user access content only during a certain time window in order to make it more interesting and emphasise the familiar excitement of a live event and its real time feel. We suggest that others experiment with physical and other positive restrictions in their designs. On the other hand, if desired, the tight union of space and content in AR could be resolved. In our system, POI and music discovery are by no means universal. Web-based, dynamic and interactive maps could solve that.

### ***Supporting 'right here, right now' functions***

Compared with the usual 'checking out what's happening (online) right now' function, our application also supported 'what's happening now *right here*'. We therefore suggest that designers deploy the location-sensitive qualities of AR in their designs. Designs should enable quick determination of what's happening 'right here, right now', such as by a feature that shows what's on within a radius of 300 m and starting in one hour or the music that has been left in a specific location today.

Participants enjoyed the ability to spontaneously scan their environment to find entertainment for free time and promotions for places to go (live music, food and drink) situated in their vicinity. Specifically, user-created POIs allow visitors or tourists to acquaint themselves with a district in a way that radically differs from conventional mobile tourist apps with highly curated content. According to our participants, OUTMedia's UCC gave that particular city district a personal face.

### ***Experiencing place through time: supporting the accumulation of layers of urban cultural experiences***

As AR objects accumulate over time, the AR view becomes unavoidably crowded to the point that it is hard to choose a desired object for closer examination. The system could support this dimension with advanced search and filter features. Location is given, so the most meaningful filters would be time and who has left the content and content type (music, text and visuals). The simplest way to support historical accumulation might be to offer a timeline or message chain for comments. The above design implications can all be used to support serendipitous urban experiences evoked by media and places.

### ***Aspects of serendipity***

OUTMedia offered several types of serendipitous encounters with music, places and user-created annotations. The popularity of features or content was widely distributed between subjects, showing *exploration* as an aspect of serendipity, as not everyone found or liked similar items. There was also diversity as the questionnaire and interview data revealed multiple reasons for participants using the Favourite feature on POIs. In addition to genuine serendipity,

there was also pseudo-serendipity (rediscovery). Based on interviews and ResQue metrics, the application supported music interaction and discovery very well.

The data from user interaction logs show other behavioural aspects of interaction. The application was used mainly for browsing and checking out music (recommendations), which is demonstrated by the short average playback times. This was prominent when the Friend filter was activated, which indicates that the presence of social information induced 'status checking' behaviour (Oulasvirta et al. 2012), that is, the user was not necessarily interested in the POI at first, but wanted to explore it because their friend had expressed some interest in it. After browsing, participants commonly continued checking out the AR scanning mode, instead of using the application in the same manner as when the Friend filter was off. The Friend filter was perceived positively among users in the interview and survey data. The 'Soundtrack of a place', a mix of several songs for the location, received a similar reception. This suggests that a geographic and/or time-based 'music trail' type of continuous, radio-like concepts would be a topic to explore in future. This could be readily studied within the Tunaspot service found as an in-service app in Spotify, which allows users to link playlists to locations.

One limitation concerns the social media features of the application. Some of the users felt that they would have liked the ability to leave music in places themselves, and this is precisely what the complete service should enable. In the context of a design study, however, this was unfeasible. During a limited time span, the number of shared POIs accumulated would have been too low to mimic realistic social media services.

In this article, we explored dimensions of user experience for a location-based music discovery service, articulated in three themes. We also presented design insights, based on user data, into the potential design of location-based mobile AR services. We stress that the roles of location, time and various media types should all be considered carefully in designing for serendipitous location-sensitive experiences (see Figure 4). An interesting direction for future work would be to explore the 'extensions of man, restrictions of man' approach with an auditory AR for music and other audio discovery. For example, it would be interesting to study the feasibility of a simple interface with no visualisations, which would allow the discovering and hearing of music or other audio recordings that are left within hearing distance. Sounds and music from the past would come closer and fade out when walking through city streets, resulting in a city layered with diverse aural histories. Another future challenge would be to involve other contextual factors in ubiquitous music discoveries and recommendations. For example, although modern mobile devices can measure up to 20 different contextual factors, social setting is one that is still not included in automated measuring. Combining social context with location, time and different media types has the potential for totally a new kind of UX for people moving about in the city.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Funding

Part of the research underlying the work reported here was conducted while the authors worked under funding from an Academy of Finland research project, Musiquitous [grant number 129477].

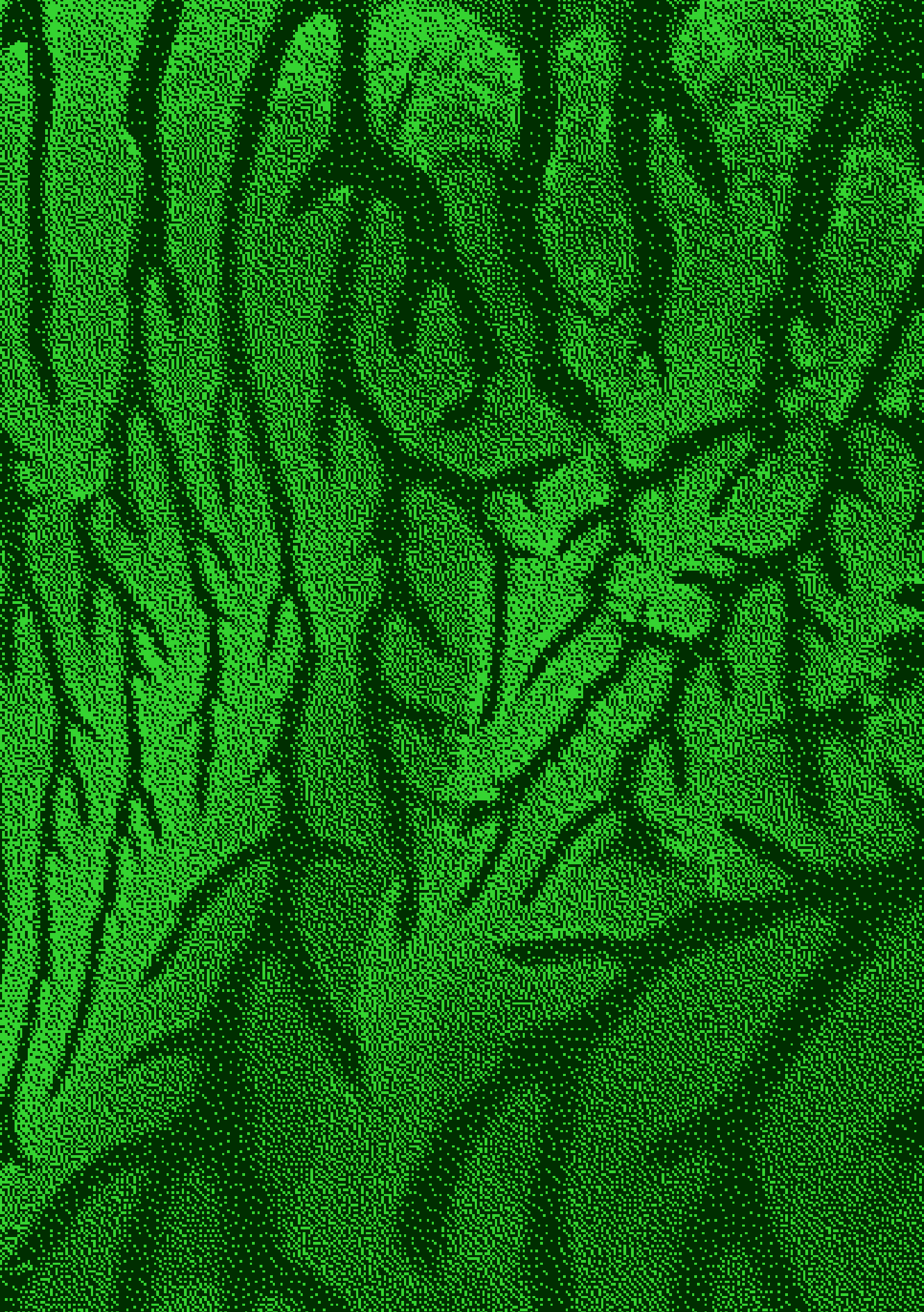
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**Article V**  
INTERACTING WITH CONTEXT  
FACTORS IN MUSIC  
RECOMMENDATION AND  
DISCOVERY

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# Interacting with Context Factors in Music Recommendation and Discovery

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## ABSTRACT

The rapid development in mobile computing has brought context sensing and information available for music recommendation as well. We reviewed 19 experimental contextual music systems and found that while the context factors of location, time, activity, and identity are adopted in a wide variety of ways, the systems mainly rely on common UI solutions for interacting with these factors. Specifically, context factors could be employed to offer explanations, transparency, and visualizations of music recommendations in more explorative ways, providing novel user experiences. Based on our review, we provide implications for design and research on future media discovery systems, which we believe can realize the great potential of context-aware content services.

## 1. Introduction

Access to recorded music is today greater than ever before. However, it is often hard to find new interesting music from the selections of millions of tracks. Numerous recommendation systems for music discovery have been developed to help the selection process. The most common recommendation techniques are collaborative filtering (CF) and content-based analysis.

In CF, user preferences for items are predicted by learning how a user has listened to music earlier. The recommender then identifies other users who have the same kind of preferences with the active user, suggesting items favored by these like-minded users and unseen by the active user (Adomavicius, 2011; Celma, 2010; Park, 2015).

As CF-based systems have several issues, including popularity bias, i.e. the recommendations tend to concentrate on the popular items instead of offering new music, other techniques have been suggested (Fleder & Hosanagar, 2007). Content-based recommendation is based on storing information describing items and offering recommendations that resemble the items the user likes. It is carried out either automatically or manually. In the automatic approach, some of the features (e.g. tempo, harmonics, or signal intensity) of music tracks are analyzed by software (Downie, 2008; Ricci, Rokach, & Shapira, 2011), while in the manual approach, experts or users classify and tag the music tracks according to, for example, genre, mood, or instrumentation (Kaminskas & Ricci, 2012). Many commonly used recommendation systems are hybrids, adopting both content analysis and CF. Popular commercial online services such as iTunes, Spotify, and YouTube typically apply CF, but content analysis and hybrid approaches are also adopted in their music recommendation features (Magno & Sable, 2008). Online personalizable radio Pandora is unique in its content analysis

approach of tagging every music track manually by musicians and musicologists (ibid.).

As music choices are heavily affected by the user's mood and other situation-dependent attributes (North, Hargreaves, & Hargreaves, 2004), context factors have recently made their way to music recommenders (Adomavicius & Tuzhilin, 2011; Ricci et al., 2011). While traditional music recommendation approaches suggest users either music (tracks or artists) or other users, contextual recommendation adds situational factors to the equation. For example, adding location as a context factor adds a third dimension, matching music to location.

Several context-aware music recommendation systems have been put forward in research and some introduced into the consumer market, with no commercial breakthroughs yet. Of the popular commercial systems, Spotify has recently started to offer curated, expert-created playlists for various moods and activities (Page & Ning, 2014).

In this review, we present the spectrum of context factors and interaction design features affecting contextual music discovery user experience (UX). Since the promises of contextual music recommenders often center around their potential for serendipitous, i.e. positively surprising, discoveries of new music, we will pay attention to in which ways the systems promote serendipity. We will investigate how the systems under review apply:

- (a) context factors
- (b) interactive features.

We reviewed 19 research systems that apply context factors for music recommendation, in most of the cases (14) including a user study. In our analysis, we also provide insights related to each context factor from the user evaluation of the systems.

Our article aims to aid researchers and designers in developing not only better music systems but also other context-aware applications. As there has not yet been a review of contextual music interfaces, the novel contribution of this article is in providing a summary of the ways context factors and the related interaction design features have been adopted for music recommendation so that innovative UX solutions can emerge from what has been suggested earlier.

The article is structured as follows: in Chapter 2, we present the conceptual background. Chapter 3 presents an overview of the groups of the reviewed systems according to their designed purpose. In Chapter 4, we present primary context factors of location, time, activity, and identity, presenting their idiosyncrasies, together with typical and nonstandard examples of the ways context factors and interaction dimensions are adopted in the systems. Observations from the user studies are presented in Chapter 5. In Chapter 6, we discuss the main findings of contextual music interactions thematically and provide concluding remarks.

## 2. Background: Conceptual Framework

Creating an unambiguous and universal categorization of context types is a research issue in itself (Dourish, 2004; Razaque, Dobson, & Nixon, 2005). After reviewing several views on context, we opted for Dey & Abowd's (1999) view of seeing *identity*, *activity*, *time*, and *location* as the primary context information types, of which the other contextual information types can be derived from. Time, location, and identity answer the fundamental situation-dependent questions of *when*, *where*, and *who*. Activity answers the question of *what* is occurring in the situation (Dey & Abowd, 1999). We discuss the concept of context in more detail in section 2.1.

Three of the reviewed systems involve *mood* as a context factor, relying on obtaining the mood value explicitly from the user (Mobile Music Genius; Lehtiniemi & Holm, 2012; InCarMusic). While mood could be assigned to any of the four primary categories or some combination of them, we leave it mainly out of our analysis, since only Lehtiniemi and Holm (2012) present a user interface (UI) solution that does not follow common user input values for mood selection (e.g. the binaries of “calm–active” and “happy–sad” in InCarMusic). We will discuss Lehtiniemi & Holm's “mood pictures” UI within the context factor activity.

Throughout the article, we use the terms *music discovery* and *music recommendation*. The former refers to the user's experience, the latter to the techniques adopted for discovery. While contextual approaches have been reviewed earlier, they have focused on recommendation techniques or usability evaluation. Jones and Pu (2007) conducted user evaluation of two popular non-contextual commercial music recommendation systems and their UIs. Kaminskas and Ricci (2012) reviewed recommendation techniques adopted in the fields of music information retrieval (MIR) and recommendation systems research, but did not review how context factors have been made available at the UI level.

Recommendations are often evaluated by their quality (e.g. relevance, novelty, serendipity), which is best evaluated by

users (Celma, 2010; Swearingen & Sinha, 2001). Instead of the perceived quality of recommendations, we analyze:

- (a) the use of *context factors* (discussed in Section 2.1),
- (b) interaction features forming a construct of *interaction adequacy*, adapted from (Jones & Pu, 2007),
- (c) *interaction metaphors and paradigms*, which can be subjected to expert analysis.

*Interaction adequacy* covers user effort, presentation, transparency, and explanations as well as scrutability and refinement. Transparency and explanations refer to communicating the user why a recommendation was made and revealing the system logic. Transparency can be seen as a design challenge while providing explanations is a solution to it; however, we use these terms together, following the previous literature on the subject. Refinement features allow users to give feedback to the system. We present both typical and nonstandard examples of how (a), (b), and (c) are applied in the systems. (Åman & Liikkanen, 2010; Jones & Pu, 2007; Konstan & Riedl, 2012; Pu & Chen, 2010; Tintarev & Masthoff, 2007; Tintarev & Masthoff, 2011).

*Metaphors and interaction paradigms* are manifested on the UI level, specifically as part of the presentation category (Figure 1). Interaction metaphors refer to the ways recommendations are presented to the user. In general, metaphors connect a set of concepts to another set of concepts, transferring meanings from one area of reality to another (Lakoff & Johnson, 1980). In the context of UI design, interaction metaphors are usually visual guides and frameworks familiar from the real world, helping users perform tasks and make sense of the computing environment at the UI level (Carroll, Mack, & Kellogg, 1991). For example, web UIs employ several metaphors from the real-world organization of books and libraries (bookmark, page, tab) for easier interaction with digital objects.

Interaction paradigms describe the ways in which the user actually interacts with music content. Despite the numerous digital music services, interaction with recorded music is still dominated by two interaction paradigms: *curated* and *on-demand* paradigms that hark back to the analog era of physical radio devices and vinyl discs (Liikkanen & Åman, 2015; Liikkanen, Amos, Cunningham, Downie, & McDonald, 2012). The logic of this division is based on dividing interactions between different abstraction levels (Te'eni & Sani-Kuperberg, 2005). On the *operational*, or executive, level, interaction is commonly defined by the

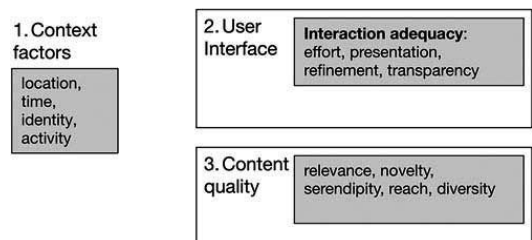


Figure 1. Model of three levels of UX for contextual music recommendation and discovery. In our review, we address context factors and dimensions of interaction adequacy. Legend: white boxes: levels of UX; gray boxes: evaluable properties.

constraints of a technology at hand (Liikkanen & Åman, 2015). For example, modern smartphones are operated by tapping interactive “buttons” on a touch screen, while the phones of early 2000s had still physical buttons for the same functions. On the *strategic* level, interactions function today as they have been functioning from the introduction of the two dominant technologies of mechanical reproduction of recorded music, radio and physical disc media. The currently dominant curated and on-demand strategic interaction paradigms match the operational level content selection modes of *tuning in* and *playlisting* (Liikkanen & Åman, 2015). The former demands only a selection of a station or channel for a continuous stream of music, while the latter is based on the selection of content and the order of play. In our review, we address typical examples and point out uncommon cases of both interaction paradigms and metaphors.

Based on our previous work on the subject (Åman & Liikkanen, 2010, 2013; Åman, Liikkanen, & Hinkka, 2015; Forsblom, Nurmi, Åman, & Liikkanen, 2012), we built an analysis framework, a descriptive model presenting the three levels of UX (context, content, and interactions) that are encountered and interacted upon by users (Figure 1).

The analysis was conducted by examining each system as they were presented in the respective articles by observing the following properties.

### Context Factors

If the system applies one or more context factor out of the four primary factors, how is it applied? Drawing from the analyzed systems’ features, we present typical and original uses of location, time, activity, and identity. As the context factors fundamentally differentiate from each other, the ways the systems apply them are addressed in the separate sections (Sections 4.1–4.4).

### Interaction Adequacy

- (1) What kind of *user effort* is required to receive a recommendation?
- (2) How is the *presentation of* recommendations implemented? Does it adopt a playlist, stream, or nonstandard presentation? What kinds of *metaphors* and *interaction paradigms* does the system adopt, if any, beyond a playlist or stream?
- (3) *Transparency*: How does the system communicate why certain recommendations were offered?
- (4) *Refinement*: What kinds of interactions does the system offer when informing the user that the recommendation was bad or providing some other form of feedback?

### User Feedback

What did the users think about the system, in terms of the use of context factors and the interactions provided? The results are presented in Chapter 5.

## 2.1. Context in Music Discovery and Recommendation

Context has been one of the central concepts in HCI since the mid-1990s. In search and discovery tasks, context is “a necessary source of meaning” (Dervin, 2003). Context can be thought of as a snapshot (Beale & Lonsdale, 2004) of all the factors that are relevant to the user and the system in a particular moment. We reviewed five views on context that emphasize and include different aspects in the concept.

For Dourish (2004), context is a relational property between objects and activities, generated through *activity*, and thus something that cannot be categorized outside a certain situation. Dourish does not present a framework for practical design work. In Krippendorff’s (2006) product semantics, *meaning* is in the center of the concept of context. For Krippendorff, context is a frame where users create meanings for design artifacts. Like Dourish, he does not offer a categorization of context types.

In a review of techniques employed in context-aware music recommendation, Kaminskas and Ricci (2012) present three context categories: user-related contextual information, environment-related contextual information, and multimedia context. However, their definition is based on MIR research and its approach on context, in which all information surrounding the music track is context, makes the scope of the concept unusefully broad (covering almost all music services) for our analysis. Specifically, we do not consider the category of multimedia context such as metadata (e.g. lyrics and track title) contextual information. For us, these data are part of the content.

Razzaque et al. (2005) reviewed previous definitions of context and provided a comprehensive context categorization. However, their categorization (user context, physical context, network context, activity context, device context, service context) includes many dimensions that are formed from the system point of view (e.g. network connectivity, device’s battery lifetime). As the focus of our review is on the context factors that are relevant for recommending music to the users, we tried to find a simpler, but still comprehensive categorization. After reviewing earlier views on context in HCI, Dey and Abowd (1999, 3–4) define context as follows:

*Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application in a situation, including the user and application themselves.*

This operational definition is directed to designers and developers working in the field of context-aware computing. It helps determine the factors that belong to the application’s context of use. If a piece of information is relevant to interaction in that particular use situation, it is part of the context. For example, in a mobile travel app for exploring the sights of a foreign city, location is relevant contextual information while a weather forecast of the user’s hometown is not.

We see that Razzaque et al.’s view is useful for technical system design and implementation, while Krippendorff’s and Dourish’s views are helpful in explaining system use: the activity with the system and the meanings people construct while using it. On the other hand, Dey & Abowd’s view is

clear, definite, and unequivocal, covering all aspects of context in a compact way. It gives designers and developers a pragmatic tool to analyze existing services and search design alternatives and potential future solutions. Moreover, it is formed by reviewing nine previous definitions of context in the HCI literature and has numerous citations (ACM Digital library citation count, as in May 2016: 259).

There is a hierarchy of importance within context types. According to Dey and Abowd (1999), certain types of context are more important than others. The *primary* context types are location, identity, activity, and time. All the other context types (i.e. *secondary*) can be derived from these. For example, a user's email address is derived from the primary category of identity. In a similar manner, in a mobile journey planner, distances to various bus stations are derivatives of location. Sometimes, multiple primary categories are needed to map a secondary context factor. For instance, meaningful forecasted weather conditions typically require location and time (Dey & Abowd, 1999). Primary context factors of time, location, and activity are mostly situation-dependent in nature, i.e. transitory and subject to change; however, identity has also more or less stationary dimensions (e.g. birthplace, gender, nationality) that characterize the user regardless of the situation, which could be involved in music recommendation as well.

For the realization of contextual services, information about context is acquired by deducing or retrieving it (1) explicitly, with the user providing the data, (2) implicitly, by means of sensing technologies, or (3) by inference from data (Adomavicius & Tuzhilin, 2011; Schmidt, Beigl, & Gellersen, 1999; Tu et al., 2013). We will apply the concepts “implicit” and “explicit” to distinguish between automated (both implicit and inferred) and user-given (explicit) context data acquisition modes. An example of explicitly entered context data is a user choosing a city (e.g. “London”) for personalized weather updates instead of the implicit localization of the user via location services.

Implicit context data can be more reliable and more granular than user-provided explicit data although they lack the meaningfulness of the information given by the user and must be computationally interpreted (Ricci et al., 2012). However, the required user effort can be minimized when automatically acquiring contextual information. In many cases, contextual data acquisition is accomplished both implicitly and explicitly in the same system. While our main focus is on the user interactions, we will also describe the ways in which various context data are acquired for the contextual music recommendations.

### 3. Overview of the Reviewed Systems

We analyzed 19 music recommendation systems that apply contextual information for personalized music discovery in order to find out the user interactions they provide for contextual music discovery, recommendation, and music listening. The reviewed systems were published between 2004 and 2015 in HCI and related forums (Figure 2). The articles were selected based on the following criteria: they presented a *research prototype* of a *contextual music application* presenting a *UI*. To ensure that all the relevant research was included, we ran multiple searches on ACM Digital library and IEEE Xplore services.

We start with an overview of the systems. Based on their design intent, we grouped the systems into three main clusters: *location-dominant*, *task-specific*, and *all-inclusive systems*. The clusters inform us about researchers' and industry's understanding of the most lucrative areas for contextual music recommendation from the last decade. Only one system fell out of the clusters. It was a prototype using “mood pictures” to produce playlists matching the depicted mood or activity (Lehtiniemi & Holm, 2012).

#### 3.1. Location-Dominant Systems: Geo-Tagged and Collocated

These systems foremost support encounters of music, places, and people in the city Tables 1 and 2. *Geo-tagged* systems offer music attached to places in urban environments and provide music in conjunction with the exploration of urban spaces. They are targeted for visitors or citizens, providing users with a new information layer of the city, containing music and sometimes other content (e.g. user comments) as well. The systems that use nearby people or devices for music discovery in *real time* are called *collocated* (Jacucci et al., 2009; Lundgren, Fischer, Reeves, & Torgersson, 2015; Seeburger, Foth, & Tjondronegoro, 2012).

#### 3.2. Task-specific systems

These systems use context factors for recommending music for certain activities. In our review, there were two systems targeted to sports and two for driving a car.

#### 3.3. Automated, All-Inclusive Systems

These systems employ multiple context factors, relying heavily on implicit context acquisition to provide an unobtrusive UX in everyday activities. “Automated” refers to implicit context acquisition that reduces the required user effort greatly.

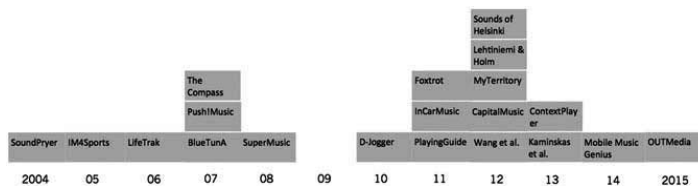


Figure 2. Timeline of the reviewed research prototypes.



Table 1. Collocated systems.

System name	Main features
BluetunA	Pre-smartphone era mobile phone app for music information sharing with nearby people.
Capital Music	Tablet app for showing album art of music currently played by nearby people.
Push!Music	Early tablet app for finding nearby users for sending and receiving music files.
The Compass	Pre-smartphone era mobile phone app showing direction and distance of other users, whose music can be downloaded.

Table 2. Geo-tagged systems.

System name	Main features
Foxtrot (Ankolekar and Sandholm, 2011)	Mobile and desktop app that automatically creates radio-like stream of geo-tagged music, ambient sounds, and comments.
MyTerritory	Mobile phone map-based app. By circumnavigating areas, they can be “conquered” by attaching music to them.
OUTMedia	Mobile phone augmented reality browser app for user-created points-of-interest (POIs) with music.
PlayingGuide	Mobile phone map-based app recommending music for POIs during touristic city itineraries.
Sounds of Helsinki	Mobile phone app with push notification recommendations of music events for urban settings.

## 4. Contextual Music Interactions

In the following sections, we review and analyze the ways in which the primary context factors of location, time, activity, and identity have been adopted in the contextual music UIs.

### 4.1. Location

Today, millions of people use their mobile devices as the main channel for accessing media content and content recommendation services as well (Ricci et al., 2012; Yang, Lu, Gupta, & Cao, 2012). It has been easy to measure location quite accurately for over a decade. In this light, it is no wonder that most of the systems utilize location (16 of 19).

While location-*aware* is a generic term for systems that utilize location information, location-*sensitivity* is a subcategory, meaning that content can be discovered or accessed *only* when close or on location (Åman et al., 2015). Examples of location-sensitive systems include OUTMedia (Åman et al., 2015) and PlayingGuide (Braunhofer, Kaminskas, & Ricci, 2011), which allow users to listen to music only when nearby or on the location.

Another distinction used in association with location is the conceptual pair of *collocated* and *co-present* users. Collocated refers to technical connectedness, e.g. by means of Wi-Fi or Bluetooth (Jacucci et al., 2009; Lundgren et al., 2015; Seeburger et al., 2012). Co-presence refers to a shared space and relationships with a social position (e.g. English pub institution), relating closely to the concept of neighborhood (de Certeau, 1984; de Certeau, Giard, & Mayol, 1998; Silverstone, 2003). A public space can be conquered at least temporarily for private use. This dimension is utilized for example in MyTerritory app, letting users “conquer” areas with music (Lehtiniemi & Ojala, 2012). By allowing users to share song selection information between collocated strangers in public urban places, Capital Music aims to result in experiences that are mixed in terms of private and shared reality. It is deliberately designed to employ

Table 3. Task-specific systems.

System name	Main features
D-Jogger	Custom hardware that applies user pace to choose and adapt the music in real time.
IM4Sports	Custom hardware that matches music with the current pace of a walker or jogger.
InCarMusic	Mobile phone app for streaming music channels based on user-input and implicit data for car travel.
Sound Pryer	Custom hardware applying early tablet computer as a shared car stereo for musical traffic encounters with other drivers.

Table 4. Automated systems.

System name	Main features
ContextPlayer	Mobile phone app recommending tracks based on context information.
Lifetrak	Mobile app for early tablet computer for automatic music stream, also user-adjustable through “Context Equalizer”.
Mobile Music Genius (Schedl et al., 2014)	Tablet app for automatic real-time contextual playlists.
SuperMusic	Mobile music player with context-aware streaming music feature.
Wang et al., 2012	Mobile app offering automatic playlists for six activities, with a manual mode option.

the nuances along the axis of public and private space. Through music discovery, it aims to facilitate communication between strangers (Seeburger et al., 2012).

At the UI level, maps are a common way to satisfy an aspect of interaction adequacy, *transparency*, i.e. telling users how the system works or why a certain recommendation was made. While most recommenders are black boxes, not revealing their system logic, transparency and explanations have proved to be crucial trust-evoking features improving recommender UX (Åman & Liikkanen, 2010; Sinha & Swearingen, 2002; Tintarev & Masthoff, 2007; Tintarev & Masthoff, 2011).

Some collocated systems (Capital Music, BluetunA) allow users to discover nearby strangers’ music, providing a potential source for serendipitous discoveries. The Compass, one of the collocated systems, provides a rare example of nonstandard UI (Figure 3). It employs a simple navigation metaphor for discovering music from nearby users’ devices (Tanaka, Valadon, & Berger, 2007). The UI has a compass needle that displays the direction and distance to



Figure 3. The Compass: Rare example of an unconventional UI metaphor.



Figure 4. OUTMedia mobile augmented reality music browser.

walk to reach the range of a Wi-Fi or Bluetooth network to exchange music files with another user. Contrary to geographic map interfaces, The Compass shows only the direction and allows user to stray, in the spirit of Situationist *dérive* or Baudelaire's *flaneur* (Baudelaire, 1863/1964; Debord, 1955/2006; Tanaka et al., 2007), potentially leading to serendipitous discoveries of not only music but places as well.

A nonstandard modification of the playlist paradigm for discovering music is exemplified by OUTMedia, a geo-tagged system that offers music discovery through fixed music-place combinations and mobile augmented reality UI. Music discovery happens by scanning the user's surroundings through the mobile phone camera with a layer of augmented reality objects hovering upon the camera view (Figure 4). It is one of the seven systems that do not rely on the basic playlist visualization of recommended music offered for discovery. The other six systems (Capital Music, ContextPlayer, D-Jogger, Lifetrak, SoundPryer, The Compass) adopt either playlist that is not visualized (following the *tuning in* paradigm) or present the playlist as an album art mosaic. Besides being an easy way to *refine* recommendations just by looking in another direction, OUTMedia UI enables the user to look toward the world, and not the screen, offering an alternative to the common mobile UX. This also provides transparency for interaction.

#### 4.2. Time

Time affects music choices directly as music preferences commonly vary according to the time of day, weekday, and between work and leisure (Bull, 2008; North et al., 2004). For example, some people want to listen to energetic music right after waking up, and many prefer slow tempo music in the late evening (Levitin, 2007). As certain activities have a close relationship to time, time is closely linked to the context factor of activity, and many activities can be described in terms of time (e.g. evening run, Sunday dinner; Reddy & Mascia, 2006). The most typical granularities of time adopted in the systems are time of day (e.g. morning, evening) and weekday (e.g. in Lifetrak, Mobile Music Genius, ContextPlayer, InCarMusic).

In the reviewed sports systems (D-Jogger, IM4Sports) time is adopted together with other context factors such as identity, heartbeat, or pace to provide recommendations to match the desired intensity of the exercise, a common sports-related

function of music (Karageorghis et al., 2009). D-Jogger employs the user's pace to dynamically choose and adapt the music in real time. In IM4Sports, user's speed and music have a two-way relationship: the desired intensity of exercise is achieved by music tempo and, in another mode, time stretching of music is adopted to match the user pace. *Spotify running* ([www.spotify.com/us/running](http://www.spotify.com/us/running)) is a commercial example of an app that employs phone accelerometer data for suggesting music that matches the user pace.

The most important dimensions of time for music recommendation include the categories of "most recently", "right now", and "near future". These functions resemble the uses of media studied in media and cultural studies (Fiske, 1990). Most recently happened events are interesting because they have news-like appeal. Events happening right now resemble live events, and part of their appeal is due to the ephemeral nature of the "live": once it has happened, it may never happen again exactly the same way. Events or media happening in the near future provide a potential agenda of what to do (events) or follow (media) next (for an analysis of time as a part of UX, see Liikkanen & Gómez, 2013). Out of these, most of the reviewed systems (e.g. Capital Music, Lifetrak, InCarMusic, OUTMedia, SoundPryer) adopt the approach of recommending music for the actual, real-time moment and situation the user is in. In several reviewed systems, music is recommended between collocated users, where not only location, but also temporal proximity is considered. Collocated systems such as Push!Music, BluetunA, and Capital Music all make use of the real-time aspect, thus providing potential for serendipitous encounters with music and other users. Sounds of Helsinki recommends festival events happening in the coming hours of the same day.

Although filtering features at the UI level are rare in the reviewed systems (for an exception, see Figure 8), more control over content may be achieved by introducing time-based filtering of recommendation histories through chronological layers of users, locations, and content genres. None of the reviewed systems offer this kind of filtering. OUTMedia (Åman et al., 2015) offers users added value by including the "most recently" UI feature for showing a playlist of the four latest tracks played near the user's location.

#### 4.3. Identity: Social Features

Identity can be looked through two lenses: (a) social media and related features that typically connect friends or friends of friends; and (b) systems that employ collocated people connect strangers. The potential for serendipity varies along the continuum of the familiarity of users: stranger-familiar stranger-friend of a friend-friend. In the other end, there are purely random encounters with strangers' music, and in the other end, friends' music. All positions along the continuum may provide serendipitous discoveries, or relevant but more familiar music. Pure randomness often decreases relevance and increases chance for novelty. In music recommender system research, this is called the trade-off between novelty and relevance (Celma, 2010). While friend's music often matches the user's taste (relevant), stranger's music has greater potential for novelty and serendipity.

Phone number, email address, birthday, social media connections, and the user's relationships to nearby people are all part of identity (Dey & Abowd, 1999; Theimer & Schilit, 1994). At first, it may appear that all subcategories of identity (e.g. gender, email, age) are not "real" contextual factors since they are not transitory. However, identity includes dimensions that are at least subject to change, such as social media connections, not to mention a user's relationships to the surrounding people in a certain situation. In our analysis, we focus on social features since the majority of identity-related interactions in the systems center around them.

Previous research on music recommender systems shows that social features increase users' loyalty to a system and increase social cohesion (Jones & Pu, 2007; Zhou, Xu, Li, Josang, & Cox, 2012). For example, personalized Internet radio Last.fm received positive perception in a study by Jones and Pu (2007). By letting 64 participants use two systems (Last.fm and Pandora) for an hour a piece, followed by an online questionnaire about item quality, interaction adequacy, and other UX dimensions, the study showed that the wide variety of social features (blog entries, tagging, sharing, etc.) of Last.fm resulted in more satisfying UXs.

In the context of social media features, identity can be seen as a construct of status updates, likings, and the shared content over time (Silfverberg et al., 2010). The most important dimensions here are the *credibility* of a person (e.g. friend, friend of a friend, or a popular DJ) or, on the other hand, the *familiarity* of a person (stranger, familiar stranger) and his/her music preferences.

Many of the reviewed systems include social media functionalities. While the most recent systems have sharing features similar to Facebook or Twitter (see ContextPlayer carousel, Figure 5), the older ones such as BluetunA employ text messaging (Baumann et al., 2007). By using different icons, BluetunA shows the user if the other users detected nearby are strangers, friends, or familiar strangers; people whom the user does not know but who have already crossed her path. BluetunA works as a vehicle for communicating one's musical identity for collocated people within proximity of some meters (Bluetooth radius), finding people with similar music taste, and if desired, to start communication by text messaging.

InCarMusic (Baltrunas et al., 2011) implements the social dimension by requiring users to create profiles. For a specific car trip, accompanying passengers who have profiles are selected from the application preferences. The system then

offers music tracks based on the personal preferences of all users combined with contextual conditions such as traffic, weather, and mood by user input. All the other systems featuring social dimensions (see Figure 9) that employ identity are based on either collocated random encounters or common social media features such as sharing and liking.

Capital Music designers believe that sharing song choices may result in further social interactions between strangers through a messaging feature (Seeburger et al., 2012). It is a collocated system, supporting anonymous sharing of music choices between collocated people and visualizes songs that are currently played in the vicinity. It aims to expand the common practice of "cocooning" with one's phone in the public space toward a location-sensitive socializing.

Taking a look at the ways social information is implemented at the UI level, ContextPlayer's "recommendation carousel" shows related information and media in diverse ways using social media services for nearby events, songs other users listen to in similar situations, videos, and the playback history (Figure 5). It works on a touch display and sideways swiping gestures (horizontal carousel) for a multifaceted UI for supporting music discovery. It is an example of *presenting details* (beyond title, artist, and album) about the recommended items as another form of transparency and explanations (Jones & Pu, 2007).

Anonymous and socially agnostic (not differentiating between friends and strangers) social interaction was also present. This feature was received positively for its potential for serendipity particularly by the users of a collocated system of Push!Music and Capital Music, although privacy issues were noted as well. For example, Capital Music users commented that music might be used as an icebreaker in communications between strangers in public spaces. However, some users were concerned about giving their location information to strangers, or receiving offending messages (Seeburger et al., 2012).

#### 4.4. Activity

People commonly choose different music to accompany different activities (Bull, 2008; Levitin, 2007; North et al., 2004). Several systems that detect user activities and automatically choose music have been suggested to overcome the often laborious task of manually creating and switching between playlists (e.g. Cunningham, Caulder, & Grout, 2008; Han, Rho, Jun, & Hwang,



Figure 5. ContextPlayer's current playing song screen and "recommendation carousel" providing details along several dimensions, including various social media.

2010; Park, Yoo, & Cho, 2006; Su, Yeh, Yu, & Tseng, 2010; Wang, Rosenblum, & Wang, 2012; Wijinalda, Pauws, Vignoli, & Stuckenschmidt, 2005). The standard way for reasoning user activity in these systems is via mobile device sensor measurements. The older reviewed systems that employ accelerometers for activity measurement often rely on using external devices (e.g. DJogger by Biehl et al., 2006, IM4Sports), while the recently designed systems apply the smartphone or tablet built-in sensors (e.g. Wang et al., 2012). Sensor data typically includes orientation and location measured by GPS, accelerometer, and gyroscope data. Beyond movement- and location-based sensors, Wang et al. (2012) apply ambient audio and lighting conditions measured by a microphone and a light sensor for producing activity-based recommendations targeted specifically at everyday activities such as working, studying, and shopping (Figure 6).

Activity is the primary context factor for sports. D-Jogger adopts the phenomenon of entrainment, i.e. the synchronization of two rhythmical processes, in this case music and user's pace, for making exercise more motivational and fun. Data are gathered from the phone accelerometer. Music changes its tempo according to the user pace, and in another mode, recommendations are made to match the user's pace (Moens, Van Noorden, & Leman, 2010). Another sports system, IM4Sports, employs heart rate and pedometer signals for synchronizing music tempo for motivation and perseverance during exercising (Wijinalda et al., 2005).

Our main observation is that many systems provide users with no interactions for controlling activity. Beyond a binary selector

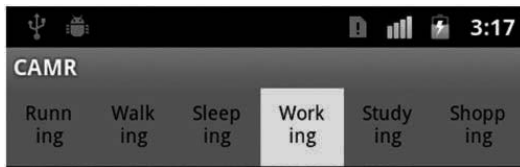


Figure 6. UI with buttons for choosing from six activities (manual mode) or showing the measured activity (auto mode) for a playlist generation (Wang et al., 2012).

for choosing between auto and manual modes, two examples from the reviewed systems show how to offer user control for activity: choosing from a list of activities (Figure 6) and adjusting the amount of effect activity has on recommendations (Figure 8).

The system by Lehtiniemi and Holm (2012) does not rely on sensor data at all. Instead, it lets users choose a photographic image of seven different activities as playlist seed. The activities include situations such as a sports event, car driving, and evening dinner. As we can see from the provided activities and the related pictures (Figure 7), activity is closely related to mood.

Often the purpose of including contextual factors in the system design is to minimize user effort. For example, Lifetrak employs automated, context-driven play to minimize interaction needs. The authors talk of “a cleaner, simpler interface that still offers powerful control” (Reddy & Mascia, 2006). In automated systems (e.g. ContextPlayer, Lifetrak, Wang et al., 2012), the application gathers context data and gives recommendations typically without user effort, updating the playlist of music stream automatically as the context changes.

Lifetrak's Context Equalizer provides a rare example of a UI that allows for adjusting the effect that context factors have on music recommendations (Figure 8). The user-adjustable mix of context factors influence the selection of tracks to be played next. Besides being an unconventional UI widget, Context Equalizer is a good example of including both automated and user-requested recommendations in a balanced way. To override the implicitly detected context factors, the user can choose to adjust the values to suit his/her situation.

While recommenders often require frequent input from the user, previous research has shown that users prefer interfaces that require little initial effort for requesting recommendations (Jones & Pu, 2007; Sinha & Swearingen, 2002). Eyes- or hands-busy activities, such as car driving or sports, naturally call for UIs that require minimal visual or haptic user effort. For instance, in Sound Pryer, minimal UI is employed for the busy activity of car driving to offer music through traffic encounters. The guiding aspects of the design process included a device mounted on the dashboard, a modest visual interface, and mostly audio-based operation (Östergren, 2004).



Figure 7. List view of pictures used for user-chosen playlist seeds (Lehtiniemi & Holm, 2012).

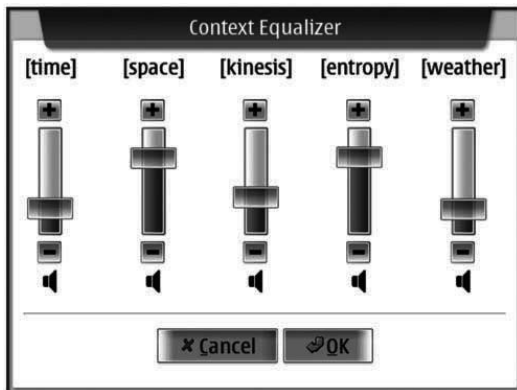


Figure 8. Context Equalizer allows overriding implicitly acquired context values.

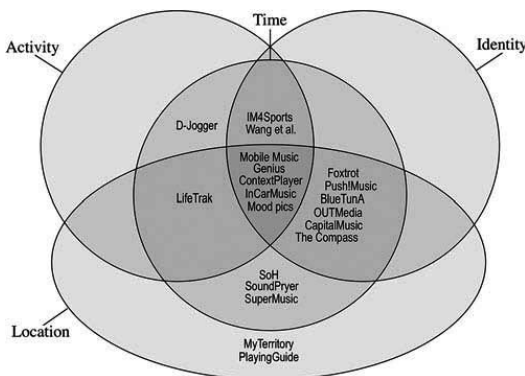


Figure 9. The primary context types as employed in the reviewed systems, showing that time and location are the most common factors, while location-time-identity is the most frequently applied combination.

#### 4.5. Summary of the Adoption of Context Factors in the Systems

*Location* is not only the dominant context factor, but it is the only factor that appears by itself in the reviewed systems. Typically, systems use location together with at least one other factor (Figure 9). Systems not applying location include two sports systems (IM4Sports, D-Jogger) that adopt user pace or heartbeat (activity) as their central contextual factor; and a system relying on playlist creation through photos of various situations (Lehtiniemi & Holm, 2012). *Time* does not function as the sole contextual factor in any of the reviewed systems. Compared with location, which was the only context factor employed alone, time typically plays a supporting role. While time is often not presented at the UI level, in many systems it is paramount to adding precision and personal feel to recommendations. Almost all of the reviewed systems (17 of 19) involve the time factor in some way (Figure 9).

Most of the systems apply context factor *identity* (13/19), and location, time, and identity is the most common combination (15/19). Like time, identity is employed not alone, but with other

primary context types for added value for music discovery. *Activity* is employed in nearly half of the systems (8 out of 19). Task-specific systems (sports, driving a car) obviously focus on activity as the main context factor for producing recommendations (Table 3). The rest of the systems involving activity apply it as one factor in a combination of context factors for automated contextual music experience (Table 4).

#### 4.6. Comparison of the Systems' Presentation of Recommendations; Visualization and User Control of Context Factors

Table 5 shows a comparison of the reviewed systems, showing (in bold) that (1) only three of the 19 systems present music tracks in a nonstandard way; (2) nine let users control context factors on the UI level (typically with common social media features, listed here as "identity"); and (3) nine offer some kind of visualization of context factors (typically location on a geographical map). The three nonstandard presentation of music tracks included CapitalMusic and ContextPlayer, presenting tracks as a variation of a list, an album art mosaic. One system (InCarMusic) let the users control all four context factors. Other than geographical map, visualizations included mobile AR view (OUTMedia, Figure 4), a compass metaphor for location (The Compass, Figure 3), and an equalizer for controlling various activity, location, and time-related dimensions (Lifetrak, Figure 8).

### 5. User Reactions to Contextual Recommendations

User studies were conducted on 14 of 19 systems. In general, the systems received positive feedback in usability and UX questionnaires. However, we focus on the results of the open-ended user data such as interviews and group discussions that are richer in conveying the user opinions. Another reason for leaving out quantitative questionnaires is that as we did not have the access to the set of questions in most of the cases, it was hard to know if the questions targeted the dimensions we were interested in, i.e. the use of context factors and the user interactions with the factors. Usually, the authors mentioned that a questionnaire was administered and then provided the results, or only a selected part of them. In the case of qualitative results, it was easy to see when the user feedback concerned the reviewed dimensions.

Table 6 gives an overview of the user studies. It highlights the number of participants, evaluation techniques, and the evaluation site. We were delighted to see that the majority of systems (10 of 14) were field studied, as studies in the wild are often necessary for mobile, contextual applications (Tamminen, Oulasvirta, Toiskallio, & Kankainen, 2004). In some studies, the concept was evaluated in a laboratory setting before the field study.

#### 5.1. Social Interaction through Music and Context Factors

Social interaction enabled by music and context factors was clearly the most commented aspect in the open-ended user data.

Table 5. Comparison of the reviewed systems.

System	System type	1. Playlist, stream, or nonstandard UI for presenting music tracks	2. User control of context factors, which?	3. Visualization of context factors, which?
BlueTuna	Collocated	Playlist	None	None
Capital Music	Collocated	Nonstandard list: Album art mosaic	Identity	None
ContextPlayer	Automated	Nonstandard list: Album art mosaic	None	Location, identity
D-Jogger	Task-specific	Stream	None	None
Foxtrot (Ankolekar and Sandholm, 2011)	Geo-tagged	Stream	Location, identity	Location, identity
IM4Sports	Task-specific	Stream	None	None
InCarMusic	Task-specific	Playlist	Location, time, activity, identity	None
Lifetrak	Automated	Stream	Location, time, activity on an EQ UI	EQ: context factor levels
Mobile Music Genius (Schedl et al., 2014)	Automated	Playlist	None	None
Lehtiniemi & Holm, 2012	Mood based	Playlist	Activity, choice of 7 photos	Photos of various situations
MyTerritory	Geo-tagged	Map & playlist	Location, identity	Location
OUTMedia	Geo-tagged	Nonstandard list: mobile augmented reality	Location, identity	Location, identity on augmented reality UI
PlayingGuide	Geo-tagged	Map & playlist	None	Location
Push!Music	Collocated	Playlist	None	None
SoundPryer	Task-specific	Stream	None	None
Sounds of Helsinki	Geo-tagged	Map & playlist	Identity	Location
SuperMusic	Automated	Playlist	None	None
The Compass	Collocated	Playlist	None	Location through a compass UI
Wang et al., 2012	Automated	Playlist	Activity	None

**Social Media Features: Creating, Sharing, and Commenting Content with Context Factors**

Word-of-mouth, together with radio, are still the main music discovery channels (Nielsen, 2012). The importance of the context factor identity is emphasized by the social media practices of sharing, liking, and commenting on content. Commenting functions as a popular electronic word-of-mouth mechanism. It is not surprising that users appreciate the social media features, even more so with an additional twist brought by other context factors such as location. Users of several studies stated that sharing one’s music and music taste is important for satisfying UX, emphasizing the need for self-expression by making their musical identities available for others (see OUTMedia, Capital Music, MyTerritory, Push! Music; Silfverberg et al., 2011).

For example, MyTerritory users appreciated the low threshold for contextual content creation and sharing. It seems that the key element in the systems relying on user-created content

Table 6. Comparison of user evaluation approaches.

System	Users	User evaluation techniques	Study site
Capital Music	5 + 13	2-stage: focus group, questionnaire	lab & field
ContextPlayer	10 + 60	2-stage: interview, questionnaire	lab & field
D-Jogger	33	questionnaire	lab
Foxtrot (Ankolekar and Sandholm, 2011)	100	questionnaire	lab
IM4Sports	6	questionnaire	lab
Lehtiniemi & Holm, 2012	40	observation, interview, questionnaire	lab & field
MyTerritory	15	interview, questionnaire	field
OUTMedia	18	questionnaire, interview	field
PlayingGuide	26	questionnaire	field
Push!Music	5	questionnaire, focus group	field
SoundPryer	13	video recording, interview	field
Sounds of Helsinki	8 + 15	2-stage: User workshop, questionnaire	lab & field
SuperMusic	42	interview, questionnaire	field
Wang et al., 2012	10	questionnaire	lab

(OUTMedia, MyTerritory, Capital Music) was motivating users to contribute by making content creation and sharing easy and user identity visible.

Users voiced the importance of appropriating systems for their own purposes. For example, Capital Music users repurposed the nickname functionality by emoticons or short messages, explaining that they wanted to describe their motivation, mood, or activity behind their music choices.

**Real-Time Social Interaction through Music and Context Factors**

Music discovery linked with real-time social interaction was particularly satisfying. For example, Push!Music allows users to send music files to other users. This function was highly appreciated, as users described receiving previously unknown music as serendipitous “treats.” Suddenly receiving new music also triggered spontaneous social interaction. The general opinion was that Push!Music was the most engaging when used in a social way, when “something was happening”, i.e. when the playlist was updating in real time with music tracks moving between participants (Hakansson, Rost, Jacobsson, & Holmquist, 2007).

Capital Music user study found that music was an ideal icebreaker for mediated social interactions (Seeburger et al., 2012). While music is very personal on the experiential level, music-related information such as album art and metadata are not personal. Sharing music-related information anonymously let the users remain in their private bubble and at the same time connect with collocated people in public spaces.

When asked how Capital Music would change their commuting experience, several users commented that they liked the app since it adds an extra level of community to the music listened through interacting people who are physically close but still anonymous. The authors emphasize that digital augmentations and mobile-mediated interactions between collocated strangers must be designed carefully in order to balance between anonymity and communal aspects (Seeburger et al., 2012).

Another real-time-related observation from the user studies concerns the common “status checking” behavior of

smartphones (Oulasvirta, Rattenbury, Ma, & Raita, 2012). During a 2-week user study, participants monitored Push! Music frequently and switched views between the playlist, the transfer list, and the list of online nearby users. User data shows that the participants enjoyed keeping track of what was happening in the application. Real-time activities such as transfers of songs triggered discussions in the group.

## 5.2. Communicating the Current Context Is Important

User data shows that unless system logic is communicated, users often feel confused about the recommendations. While the logic of sports systems is easily understood by users since the systems rely on user's activity levels measured from physical activity, the cluster of automated systems have several context factors and typically do not tell the reason for recommendation. A music stream without explanations may result in an enjoyable and effortless UX, but providing users with some transparency could result even in better UX (Lehtiniemi, 2008; Okada, Karlsson, Sardinha, & Noletto, 2013; Wang et al., 2012).

The need for transparency is illustrated by the SuperMusic (Lehtiniemi, 2008) users, stating that they had difficulties in understanding how the concept of "situations" affected the suggested recommendations. This is because the system did not reveal how the system had produced the recommendations. Around 63% of the users felt that it was important to see the recommendation criteria and that the explanations should be more descriptive and detailed than those provided by the system. Almost half of the ContextPlayer users suggested that notifications of context changes or the reason for receiving specific recommendations should be reflected in the UI (Okada et al., 2013). It seems that it is vital to show or tell why recommendations were made, even more so in the automated contextual systems playing music without request.

SoundPryer user study found that visualizing the source of music recommendation was rewarding. Users appreciated being able to identify the source of recommendation by seeing which nearby car was the source of music. In Wang et al.'s (2012) system, there were interactive buttons for six different activities. Some users wanted more categories for showing the current context more accurately and for interacting with them as seeds for playlists.

Summing up, observations from the user data show that users specifically appreciated features that utilize context factors for enabling social interaction and explaining the system logic on the interface level.

## 6. Discussion

In this article, we reviewed 19 contextual music recommendation systems and analyzed how primary context factors (time, location, identity, and activity) were adopted for interactive music recommendation and discovery. Location was the dominant context factor and location-time-identity the most common combination. While finding out that some systems help users by communicating their system logic, most of the systems could have been improved by developing the interfaces in terms of transparency, explanations, visualizations, and refinement.

We also reviewed user research results related to the 19 systems. Based on the review findings, we present design implications in Section 6.3. The main findings can be summarized as follows:

- Maps are the typical way of presenting location-based recommendations, be it discovery through collocated users or static geo-located music.
- Social media features, together with context factors, help in supporting serendipitous discoveries.
- Automated, unobtrusive contextual listening experience must be maintained by recommendation techniques that provide contextually relevant results and explain the system logic before the use.
- Filtering features help in browsing content accumulated over time.
- The systems could be improved with novel, interactive ways for transparency and explanations, presentation, and refinement of recommendations.
- Although list view presentation of recommendation results prevails, more information could be shown by using innovative visualizations.
- Multifunctional, interactive UI features are an effective way of interacting with context factors underlying the recommendations.

### 6.1. System Types and Their Characteristics

Four clusters were formed from the reviewed systems: automated, collocated, geo-tagged, and task-specific. Each group has its idiosyncrasies in terms of the adoption of context features and interaction dimensions that support their designed purpose.

Automated systems typically aim for unobtrusive UX by acquiring the context data implicitly. They provide the user with an automatic stream of music tailored to the current situation in a proactive way. These systems usually adopt multiple context factors in an all-inclusive approach, aiming to cover the user's situation completely. Interactions are typically minimal, so that the user can go on with his everyday activities uninterrupted. However, users often find it hard to understand why a certain recommendation was made. Therefore, transparency and explanations should be provided at the beginning of the system use, and, in order to maintain the "automated" unobtrusive listening UX, the recommender should be made technically so good that users are able to easily understand the recommendation results without needing to make new requests regularly.

Collocated systems exploit nearby people and their music to enable context-sensitive experiences that can lead to further social interaction with other users. Music-related encounters with other people function as an alternative to the common practice of cocooning with one's phone in public places. In these systems, location-time-identity is the dominant context factor combination.

Systems offering geo-tagged music differ from collocated systems in that they allow finding places with music tagged on them. They are location-dominant and often offer map

visualization for recommendation transparency. A challenge for these systems, if made commercially available, is finding interesting content from the potentially great volume of content accumulated over time. We suggest including filtering features based on, for instance, time or identity, which allows means for browsing the accumulated content.

In our review, there were two task-specific systems for both car driving and sports. They aimed to offer added value for the task at hand by increasing motivation by activity inference (sport systems), music that matches the overall driving situation by combining various implicitly and explicitly acquired context data (InCarMusic), or sharing music stream during temporary traffic encounters (Sound Pryer).

## 6.2. Observations about Interaction Adequacy

As with traditional recommendation systems, transparency and explanations of recommendations have a key role in contextual systems. Since some of the systems reveal their system logic immediately and intuitively (e.g. MyTerritory, The Compass), thus explicating how the context factors are employed for offering recommendations, some may argue that contextual systems do not need explanations to the same extent as non-contextual systems. This is true, for example, when the logic is communicated through an obvious feature, such as a map telling that an item was recommended because of the user's close proximity. However, when transparency is not intuitively revealed, it needs to be communicated to the users.

User data provides more evidence on the importance of transparency, suggesting that unless system logic is communicated, users often feel confused about the recommendations. For instance, the users of SuperMusic (Lehtiniemi, 2008) and ContextPlayer (Okada et al., 2013) stated they had difficulty understanding how the concept of "situations" affected the suggested recommendations, since the system did not show the current context factors explicitly. In many cases, the effect of context factors could be communicated to the users by applying interaction and visual features such as timelines, sliders, dials, or non-geographic maps. However, it is surprising that most of the systems do not use the opportunity of utilizing context factors for advanced and nonstandard visualizations that go beyond the typical list view (Table 5).

The contextual factors themselves provide a wide array of information and great potential for visual explanations that allow for much interesting UX. Most systems employ several context factors simultaneously, so visualizations could show the ratio of context factors currently affecting the recommendations as well (see Context EQ Figure 8). Giving the user explanation about why a piece of music was recommended in that particular situation and to that particular person, the perceived quality of the recommendation could be increased. This is because often the why is as important as what is recommended (Celma, 2010).

Presentation of recommendations is crucial for the acceptance of the system (Konstan & Riedl, 2012; Ricci et al., 2012). Explanations must be presented and well-presented recommendations also give the user clues why the recommendation was made. A list view of query results dominates the design of recommenders in general (Ricci et al., 2012) and is a de facto

standard in digital music UIs as well (cf. the playlist paradigm). The reviewed contextual systems mostly follow the dominant interaction paradigms and content selection modes of tuning in to either a curated stream or a playlist (Liikkanen & Åman, 2015). However, in the common list view presentation, a lot of information is lost. More information can be shown, for instance, by using (non-geographic) two- or three-dimensional maps that visualize the relative similarity of items, grouping similar items close to each other (Gretarsson et al., 2010). None of the reviewed systems tried to embed additional explanations within the list format.

Refinement and feedback features inspire trust in a system (Jawaheer, Weller, & Kostkova, 2014; Kay, 2006; Tintarev & Masthoff, 2007; Tintarev & Masthoff, 2011). As in music recommender UIs in general (Åman & Liikkanen, 2010), only a few of the reviewed contextual systems have interactive features for scrutability or refinement (e.g. Lifetrak).

Well-designed UI features can successfully serve several purposes. For example, Lifetrak's Context Equalizer (see Figure 8) functions as a combined refinement, scrutability, user feedback and transparency aid. Furthermore, it gives user-controlled means to acquiring potentially serendipitous music recommendations through more informative visualization than a mere list.

Although modern devices and software techniques allow for experimenting with a wide variety of nonstandard interactions and visualizations, we found out that most of the systems rely on standard UI features for interacting with contextual factors (Table 5). Nonstandard and experimental UIs for music and context factor interaction may draw inspiration for example from game interfaces that commonly deploy real-time data. Another area of potential future research is in lifestyle and health applications. For example, visualizations of biophysical data could be used in media discovery as well. Refinement features could involve 2D maps wherein context factors could be placed in weighted order as search keywords, as Andolina et al. (2015) suggest. Another refinement strategy would be to use a query result as seed for a new query, as in some studies (Baur, Boring, & Butz, 2010; Klouche et al., 2015). By communicating in which ways the contextual features work and actually letting users play with them, better UX could be achieved.

Our observations of music interaction paradigms replicate the findings of Liikkanen and Åman's (2015) study on the case of online music services. Contextual music recommendations systems rely on the dominant interaction paradigms of playlist and radio metaphors. The rare exceptions include compass and equalizer metaphors in two reviewed systems. Although dominant paradigms are well-established, there are hundreds of millions of users with unique use situations, music tastes, cultures, needs, and desires; it is thus surprising and inspiring that the potential for innovative visualizations, and interactions with music through context factors, is yet to be realized.

## 6.3. Implications for Design

We encourage designers to experiment with the following design implications.



### Visual and Interactive Explanations

Explore alternatives to textual explanations by offering intuitive visual and interactive UI elements that communicate the system logic or explain why a recommendation was made. Offer users interactions for adjusting the effect of context factors driving the recommendations (for an example, see Figure 8).

### Automated Contextual Music Stream Needs Explanations Too

Automated, unobtrusive contextual listening experience must be maintained by recommendation techniques that offer precise context-aware recommendation results and by explaining the system logic before the use.

### Filtering Accumulated Content

Include filtering features, such as timelines, sliders, or dials, based on for example time or identity for the faceted browsing of the content accumulated over time.

### Multifunctional UI Features

Explore with UI elements and metaphors that can take care of several interactional functions. By combining several functions in one UI feature, simpler, more rewarding UX may be provided. Multifunctional UI features are also an economic option for interacting with context factors.

## 7. Conclusion

Our main contribution in this study has been in pointing out that while context factors have been included in music recommendation in a number of ways that follow standard playlist and radio-like stream paradigms, innovative and nonstandard interactions and visualizations for context factors are mostly nonexistent. Reviewing user feedback showed that by applying context factors for enabling social interaction and explaining the system logic were especially appreciated by the users.

Beyond contextual music services, our findings can be applied in designing and studying other contextual media services, including various media content such as video, text, audio notes, spoken word, or photos, either curated or user-created. There have been relatively few studies about how to adopt context factors and the related interactions for other media content discovery. For example, Bentley & Basapur (2012), Vihavainen, Mate, Liikkanen, & Curcio (2012), Vihavainen, Mate, Seppälä, Cricri, & Curcio (2011), and Zhang et al. (2012) have studied media discovery (video, photos) and the related social dimensions, but with little focus on interactions or the visualizations of context factors.

Our contribution complements the research on context-aware media applications and services by pointing out the need for exploring novel ways of interaction and visualization. Our findings are applicable to the design of other areas of contextual services, aiming for the recommendation and discovery of video, photos, and other, either user-created or commercially provided content. In conclusion, we hope that our review can help in realizing the great potential in context-aware, personalizable media services.

One limitation concerning the study is that it was conducted as a review. This is because we did not have access to the working prototypes, only articles on them. If the systems were available for

user evaluation, that would potentially yield interesting results. Another limitation concerns the systems being not fully comparable with each other, e.g. there were systems designed to accompany a certain task (car driving, sports) and others targeted for non-specified activities (moving about in the city). Therefore, it may be argued that our framework of analysis did not give a balanced treatment to the systems. Still, within our selection criteria (context-aware music recommender featuring a UI and user-studied), we believe that we have produced a fruitful review, mapping out the ways in which context factors were applied for music recommendation and discovery.

### 7.1. Future Work

Interaction features that did not occur in the reviewed systems include browsing content by histories of use, places, users, and activities, but we encourage designers to experiment with them, e.g. by adopting interactive timelines. An example of a potential time-based concept for music discovery would be filtering content by the release date of a track combined with location to promote local artists. Timelines or other visualizations can help in filtering content and fulfill the functions of each of the dimensions of interaction adequacy (user effort, transparency, presentation, refinement). Real-time recommendations and interactions have great potential for rewarding UXs, as they make the users feel that something is happening right now and they are part of it. This resembles the feel of following a live event, and it is one of the dimensions we encourage to experiment with and support in contextual media systems.

In the modern ubiquitous media environment, it is gradually becoming common to anticipate that recommenders detect the context and offer recommendations when needed and without request. Therefore, proactive recommendations (Ricci 2012) that utilize context factors is a lucrative direction for future work.

While stream and playlist paradigms will prevail also in the future, by exploring modifications such as mobile-augmented reality, compass, or equalizer metaphors reviewed in this article, more interesting UX with music recommendations and music interactions could be provided.

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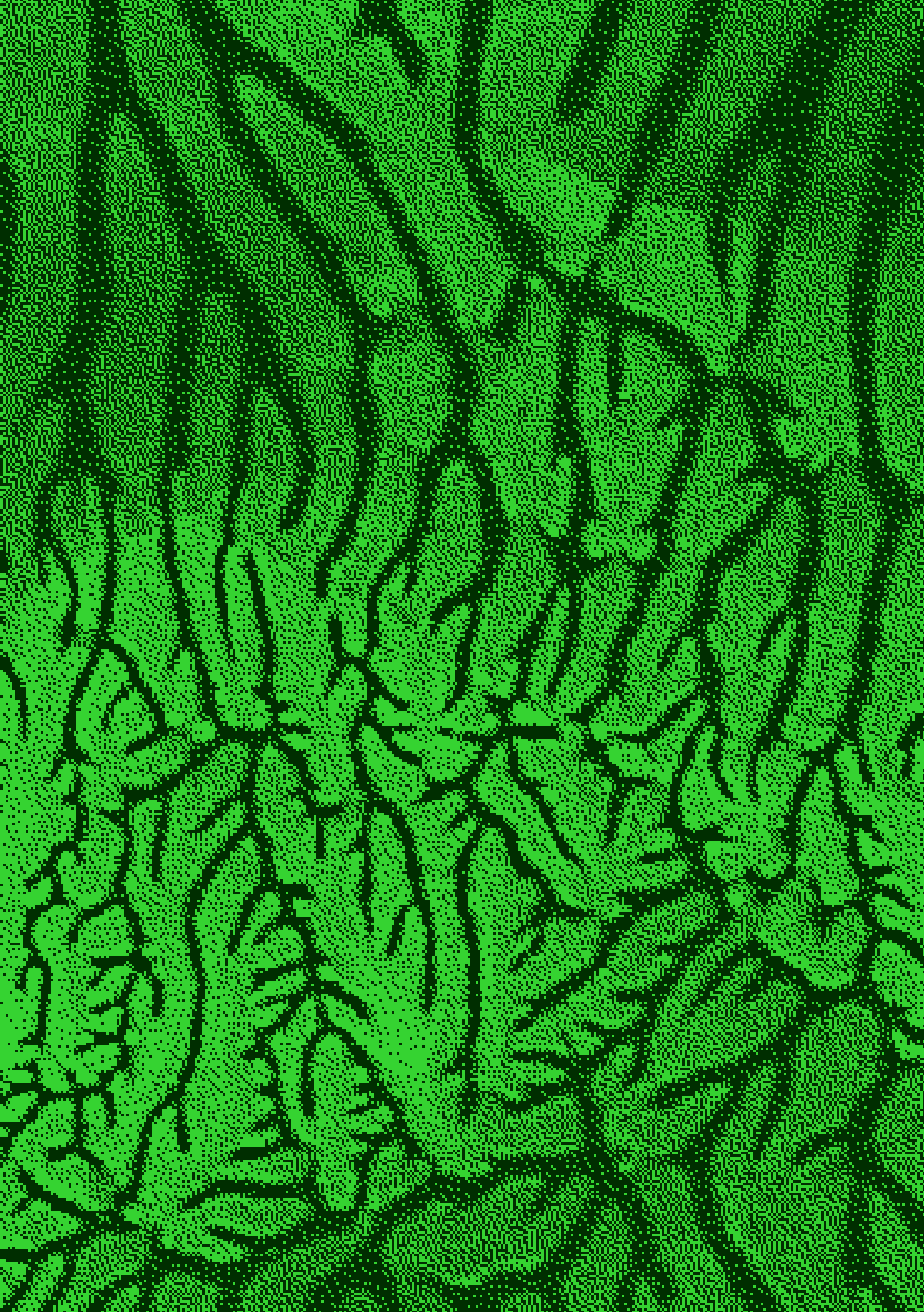
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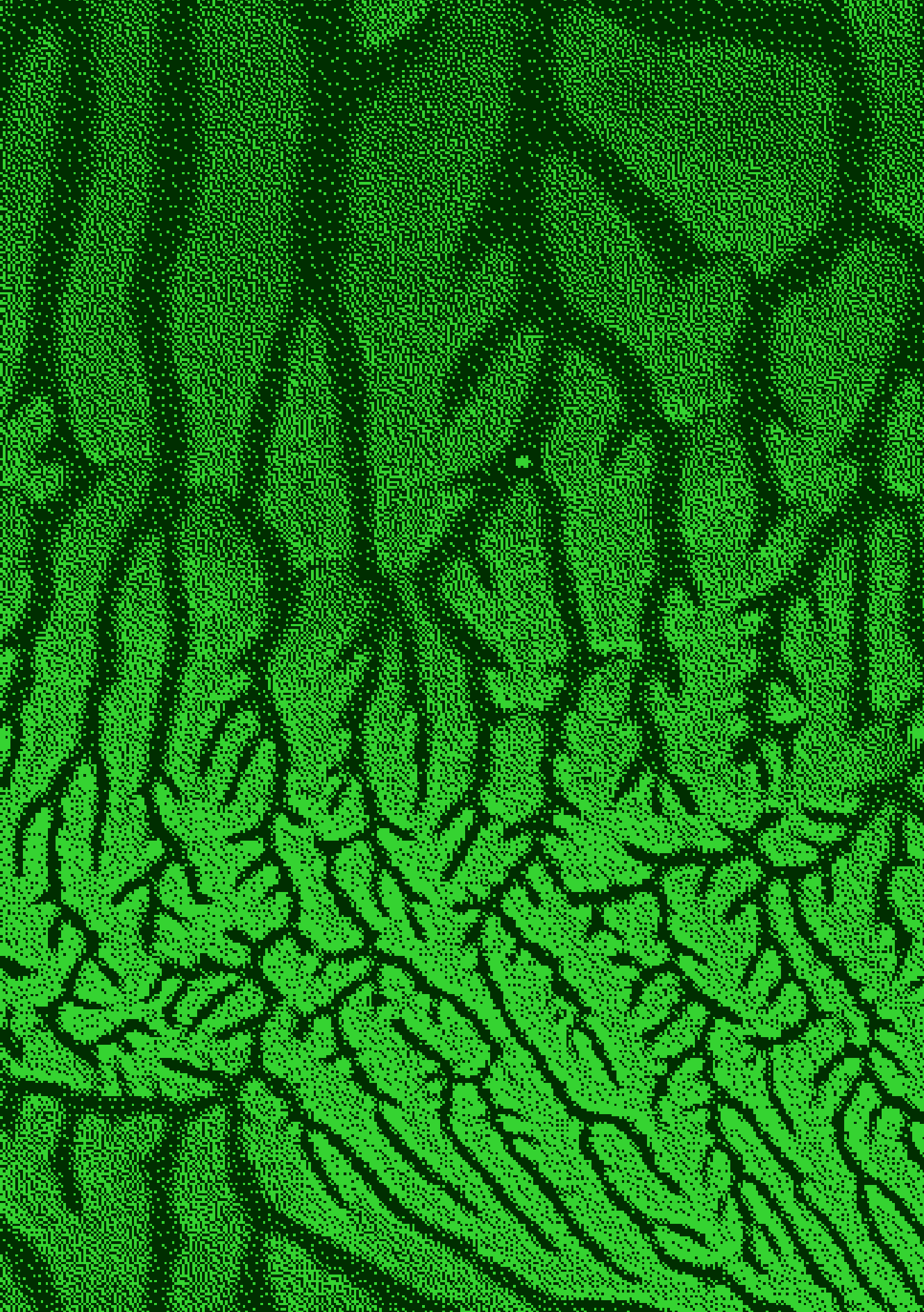
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the  $\mathbb{R}^n$ -valued function  $\mathbf{f}$  is a solution of the system (1) if and only if

$$\mathbf{f}'(x) = \mathbf{A}(x)\mathbf{f}(x) + \mathbf{b}(x) \quad (2)$$

where  $\mathbf{A}(x) = (a_{ij}(x))_{i,j=1}^n$  and  $\mathbf{b}(x) = (b_i(x))_{i=1}^n$  are  $n \times n$  and  $n \times 1$  matrices, respectively, of continuous functions on  $I$ .

Let  $\mathbf{f}_1, \dots, \mathbf{f}_n$  be  $n$  linearly independent solutions of the homogeneous system

$$\mathbf{f}'(x) = \mathbf{A}(x)\mathbf{f}(x) \quad (3)$$

and let  $\mathbf{f}_0$  be a particular solution of the inhomogeneous system (2). Then the general solution of (2) is

$$\mathbf{f}(x) = \mathbf{f}_0(x) + c_1\mathbf{f}_1(x) + \dots + c_n\mathbf{f}_n(x) \quad (4)$$

where  $c_1, \dots, c_n$  are arbitrary constants. Let  $\mathbf{f}_0$  be the solution of (2) satisfying the initial condition

$$\mathbf{f}_0(x_0) = \mathbf{f}_0 \quad (5)$$

where  $x_0 \in I$  and  $\mathbf{f}_0 \in \mathbb{R}^n$ . Then the solution of (2) satisfying (5) is

$$\mathbf{f}(x) = \mathbf{f}_0(x) + c_1\mathbf{f}_1(x) + \dots + c_n\mathbf{f}_n(x) \quad (6)$$

where  $c_1, \dots, c_n$  are constants such that  $\mathbf{f}_0(x_0) + c_1\mathbf{f}_1(x_0) + \dots + c_n\mathbf{f}_n(x_0) = \mathbf{f}_0$ .

Let  $\mathbf{f}_0$  be the solution of (2) satisfying the boundary condition

$$\mathbf{f}_0(x_1) = \mathbf{f}_1 \quad (7)$$

where  $x_1 \in I$  and  $\mathbf{f}_1 \in \mathbb{R}^n$ . Then the solution of (2) satisfying (7) is

$$\mathbf{f}(x) = \mathbf{f}_0(x) + c_1\mathbf{f}_1(x) + \dots + c_n\mathbf{f}_n(x) \quad (8)$$

where  $c_1, \dots, c_n$  are constants such that  $\mathbf{f}_0(x_1) + c_1\mathbf{f}_1(x_1) + \dots + c_n\mathbf{f}_n(x_1) = \mathbf{f}_1$ .

Let  $\mathbf{f}_0$  be the solution of (2) satisfying the boundary condition

$$\mathbf{f}_0(x_0) = \mathbf{f}_0 \quad (9)$$

and the boundary condition

$$\mathbf{f}_0(x_1) = \mathbf{f}_1 \quad (10)$$

