Universität Bremen

GangKlang - Sonic Interaction Design for Walking Experiences in Everyday Life

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Dissertation

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To Sebastian

"The visual persists, whereas the audible vanishes in time. Seeing deals with what is steady and permanent, while hearing deals with what is fleeting, ephemeral and event-based. Thus, while seeing affords reviewing, control and reassurance, hearing demands attentiveness to the moment, being aware of the unique, openness for the event..."

— Welsch, 1996, p.247-8

Abstract

Interactive systems that track the user's physical activity and respond with sonic feedback in real time open a wide range of possibilities to design for the experience of daily activities such as walking. This thesis argues that most often the outcome of the activity is at the center of design considerations which leads to interactions that support goal-oriented experiences. Psychological studies suggest that drawing attention to output might diminish the enjoyment of an activity, and that positive experiences arise when a person is doing an activity for its own sake. Considering this divergence, this thesis explores an alternative design approach and presents *GangKlang*. *GangKlang* is a concept for designing interactive sound with the purpose to enhance the walker's experience of the unfolding process; independent from motives and goals. The thesis highlights the specific challenges posed by this objective and uses the design and development of prototypes of interactive sound for walking to generate design solutions. A walking model *Walking Phrases* and a translation framework *GangKlang-Translations* are presented as key contributions. *Walking Phrases* is a process model of everyday walking that builds on the change of the walker's movements to derive contextual information. *GangKlang-Translations* includes constructs to translate walking information into sonic events that organize in an overall sonic expression. The framework further contains a strategy named *Sonic Seduction* for gradually influencing the walker's experience in order to foreground the walking process itself. Finally, the *GangKlang* concept is evaluated in a qualitative study that explores how the interactive sonic expression bear's on the walker's experience in everyday life. Focusing on a design which strengthens the experience of the activity process, this thesis establishes an alternative approach to design interactive sound for walking experiences in everyday life.

Kurzfassung

Interaktive Systeme, die Körperbewegung erfassen und in Echtzeit mit akustischem Feedback reagieren, eröffnen eine Vielzahl von Gestaltungsmöglichkeiten für das Erleben von Alltagstätigkeiten, wie zum Beispiel das Gehen. Verbreitete Designansätze stellen das Ergebnis einer Tätigkeit in den Mittelpunkt der Gestaltungsentscheidungen und bringen Interaktionsmechanismen hervor, die vorrangig ein zielorientiertes Erleben begünstigen. Wie psychologische Studien darlegen, kann die verstärkte Aufmerksamkeit auf das Ergebnis einer Tätigkeit jedoch die Freude an der Ausübung selbst mindern. Ein positives Erleben entsteht vor allem dann, wenn eine Tätigkeit um ihrer selbst willen ausgeführt wird.

Die vorliegende Arbeit entwickelt, unter dem Titel *GangKlang* einen alternativen Gestaltungsansatz: ein Konzept für die Gestaltung interaktiver Klänge, mit dem Ziel, das Erleben des sich entfaltenden Prozesses selbst zu verstärken. Die mit diesem Konzept einhergehenden Herausforderungen werden beleuchtet und die Gestaltung und Implementation von Prototypen genutzt, um Designlösungen zu erarbeiten. Als Schlüsselbeiträge werden das Gehmodell *Walking Phrases* und das Übersetzungsframework *GangKlang-Translations* vorgestellt. *Walking Phrases* ist ein Prozessmodell der Gehtätigkeit, das die Veränderung der Gehbewegung nutzt um kontextuelle Informationen abzuleiten. *GangKlang-Translations* umfasst Konstrukte zur Übersetzung von Gehinformationen in klangliche Ereignisse, die sich in einem klanglichen Ausdruck organisieren. Das Framework nutzt eine Strategie namens *Sonic Seduction*, um den sich entfaltenden Gehprozess in den Erlebensvordergrund zu rücken. Das *GangKlang* Konzept wird in einer qualitativen Studie evaluiert, die die Wirkungsweise interaktiver Klänge auf das Geherleben im Alltag untersucht.

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Nassrin Hajinejad
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1 Introduction

> *"... that each thing, in what it brings into meaningful evidence and in the specific manner in which it does so, has an orienting, world-illustrating function."*
>
> — Heubach, 2014, p.134

Interactive technologies are progressively populating our world and becoming increasingly integrated and self-evident in our daily activities. We use mobile applications to carry out all kinds of daily activities, such as commuting to work, organizing our sports exercises or finding a nice restaurant. More and more activities, both professional and private ones, are mediated by mobile apps, and the way they are designed is increasingly influencing how we experience the world, how we perceive, interpret and act. Depending on their particular design, apps for physical activities "encourage certain movements, certain aesthetic experiences, certain practices and understandings of our bodies – while not encouraging others." (Kristina Höök et al., 2018, p.2). Smartphones fitted with a variety of sensors have brought forward a wide range of applications that track the user's physical activity and provide visual, audio or haptic feedback in real-time (augmentation apps). By providing feedback in real time, augmentation apps draw the user's attention to selected aspects of their activity, thereby influencing the user's experiences. For instance, ordinary navigation apps propose the shortest and fastest way to a target destination, thereby drawing the user's attention primarily to the aspect of covering the distance efficiently between one's own location and the place of destination. Alternative approaches that take into account the emotional pleasantness of routes, suggest slightly longer routes, however drawing user's attention to the emotional quality of the environment (see Quercia, Schifanella, and Aiello, 2014). Hence, augmentation apps are a powerful means to alter the user's experience of an activity and to design for it. In recognition of the influential power of interactive technology on the way people carry out and experience daily activities, one question has gained more and more importance in Human-Computer Interaction (HCI): *how can we design interactive technologies that enhance people's experiences of everyday activities?* In particular, this question guides designers and researchers in the emerging field of positive technology which puts the user's experiences in the center of design and explores interaction strategies to support it (Calvo and Peters, 2014; Kitson, Prpa, and Riecke, 2018).

1.1 Background

This thesis has grown in context of the BMBF[1] research project *Flow-Machines: body movement and sound*[2] (Grüter, Bogutzky, and Hajinejad, 2017). The *Flow-Machines* project (FM project) focused on increasing a person's intrinsic walking motivation by means of mobile applications that specifically address, and positively influence, the walker's experience. Against the background of the sedentary lifestyle and its various related health risks (such as obesity, respiratory problems and increased heart rate), there is a strong need for interactive systems that support people's motivation for physical activity. Walking has great potential to improve and maintain mental and physical health (Lee and Buchner, 2008; Morris and Hardman, 1997). Besides its general benefits for physical fitness, walking supports cognitive performance and slows cognitive decline, which is a major issue in preventing dementia (Weuve J et al., 2004). On a psychological level, walking has been proved to reduce depression (Robertson et al., 2012). On a physiological level, walking prevents the development of heart diseases (Hanson and Jones, 2015). Ordinary walking is accessible to everyone, an effortless beginning of any kind of sporting activity, appealing to overweight and elderly people and easily integrated in daily routines.

[1]Funded by the German Federal Ministry of Education and Research from 2012-2015 (03FH084PX2).
[2]Original German title: Flow-Maschinen: Körperbewegung und Klang

A large number of mobile applications that purport to motivate walking use external stimulation principles and resources, effectively influencing the subject to follow a pattern of preset behavior motifs. Quantified-self apps model and mediate walking as a goal-directed activity and rely on users' interest in self-optimization. While this approach is useful, e.g. for contexts when users are already self-motivated to achieve some personal performance or competitive measure, there are limitations to it when people lack motivation. This approach focuses on utilitarian aspects only and neglects experiential aspects of walking that are decisive for users' behavior. Generally, a combination of being interested in the outcomes of an activity (extrinsic motivation) and enjoying the experiential qualities (intrinsic motivation) motivate a person to do an activity, while one or the other may predominate in the overall experience. The quantified-self approach provides a lens that predominantly draws attention of the users to quantitative outcomes, promoting a mostly rationalized relationship with the walking activity. By foregrounding primarily utilitarian aspects of walking, these apps might diminish the user's intrinsic motivation and have the opposite effect. In fact, studying the impact of quantified-self applications on peoples' experiences, Etkin points out that "Measurement is a powerful tool. But in addition to influencing output, it also impacts how we see and experience various activities." (Etkin, 2016, p.42). The author concludes that "By drawing attention to output, measurement can make enjoyable activities feel more like work, which reduces their enjoyment. As a result, measurement can decrease continued engagement in the activity and subjective well-being." (ibid., p.2).

1.1.1 Facilitating walking experiences

Walking is a directed everyday activity. Besides its benefits to health, walking is primarily a means to reach a target destination (Longo et al., 2015): we walk to get to work, to visit friends or to go shopping. Thus, our daily routines provide plenty of extrinsic motivation for walking. However, people's motivation and decision to walk is not only based on pragmatic qualities but also experiential ones (Eslambolchilar, M. Bødker, and Chamberlain, 2016). In contrast to the predominant utilitarian-oriented approach, the strategy of the *Flow-Machines* project was to encourage walking by means of mobile applications that specifically address, and positively influence, the walking experience. This design strategy draws on findings from flow research, which reveal that having positive experiences of an activity contributes to a person's motivation for doing it. The concept of flow as introduced by Csikszentmihalyi (1975) conceptualizes immersive experiences in games and in everyday life. The term flow is used to describe "[. . .] a subjective state that people report when they are completely involved in something to the point of forgetting time, fatigue, and everything else but the activity itself" (Csikszentmihalyi, Abuhamdeh, and Nakamura, 2005, p.600). The phenomenon characterizes the autotelic nature of an activity, a „ [...] self-contained activity, one that is done not with the expectation of some future benefit, but simply because the doing itself is the reward." (Csikszentmihalyi, 2013, p.67). What is particularly intriguing about the flow experience is that it provides "a powerful motivating force" (Csikszentmihalyi, Abuhamdeh, and Nakamura, 2005, p.602). On this account, the flow concept is applied in various disciplines ranging from activities of the working world to leisure time activities such as playing games and is one of the most prominent concepts underlying "the design and development of technology to support psychological wellbeing and human potential" (Calvo and Peters, 2014, p.2). As flow fosters immersion and engagement, it serves as a basis for designing games (e.g. Nacke and Lindley, 2009) and rehabilitation measures (e.g. Middleton and Ward, 2012). The FM project's activities were organized in three interconnected strands:

- process-oriented modeling of walking,
- measuring experiential qualities of walking,
- and enhancing the walker's experience through interactive sounds.

As a project member, I was mainly working on the last strand and investigated how the walker's experience can be positively supported by means of interactive sounds. Interactive sounds are to be understood in this thesis in a broad sense as referring to sonic feedback provided by an interactive system. These sounds are triggered and modified along the user's activity process. Interactive sounds arise, evolve and end with the user's activity.

1.1.2 Using interactive sound for walking

Sound is an inherent dimension of our everyday activities mediating our interactions with the environment. There are two distinguishing peculiarities of the medium sound that make it particularly valuable to design for the experience of physical activity in the mobile context. First, addressing the sense of hearing is particularly suitable for interaction design in the mobile context. Using sonic feedback allows us to provide activity-related information while preserving the user's mobility. Second, sound is an effective means to alter physical movement and transform experiences. Listening to music, many people tend to intuitively follow the rhythm by nodding their heads, drumming with their fingers or tapping with their feet. In a nutshell, this movement inducing effect of sound can be explained as follows: when we perceive sound, we do this by imitating mentally or physically the original sound-creating movement mentally or physically. Or in other words "[...] sound, musical as well as everyday sounds, is perceived on the basis of imagery of the way the sound process might be produced by movements." (Haga, 2008, p.7). We make use of the interconnection [3] between sound, body movement and experience in our daily life, when we intuitively choose a specific kind of music to induce, sustain or modulate a particular degree of physical arousal and to fuel an aspired mood. We choose activating music to stimulate dancing and exuberance on a party, we select energizing beats to do sports exercises and fuel a fighting spirit, and we go for calming sounds to relieve tense muscles and quieten down.

Drawing on the interrelationship of sound and body movement, scholars in

[3] The reciprocal effect of auditory stimuli and body movement has been long acknowledged and is subject to research studies in various disciplines such as music theory (Godøy, 2003; GodøY and Leman, 2010), cognitive psychology (Hommel et al., 2001; Kohler et al., 2002) and sports (Karageorghis and Priest, 2012).

HCI investigate the potential of sonic feedback to exert subtle influence on a person's performance and experience of physical activity in general and on walking in particular. In this context, the type of support that is provided by interactive sound varies depending upon the field of application. Looking on physical activity in general, Höner et al. (2011, p-525) differentiates between three application fields: "health-promoting exercises in rehabilitation programs (e.g., movements in physiotherapy, therapeutic games), fun-related movements in entertaining games (e.g., playing computer or sports games) and performance-related movements in competitive sport (e.g., diagnostics and training)". In sports and rehabilitation, the movement inducing effect of sound is used as a means to guide and optimize walking movement (Ford et al., 2010; Prassas et al., 1997). In computer games and virtual reality, sound is used to convey movement properties of the game character and material properties of virtual objects. Here, sonic attributes are used to "re-materialize" [4] the player's footsteps and to increase the player's immersion into simulated environments. Moreover, soundscapes have been studied as auditory landmarks in virtual environments and shown to have a positive influence on users' navigational abilities and immersive experience (Chandrasekera, Yoon, and D'Souza, 2015). Artistic installations use interactive soundscapes that react to the user's physical movement to influence the walker's sense of place and as a means to support engagement with the environment and to facilitate immersion (Paterson and Conway, 2014). "By augmenting an urban space, places and activities that were previously viewed as mundane become reinterpreted, revealing details and experiences that were unseen, thereby providing a rich and new encounter of this new world." (Paterson and Conway, 2013, p.125).

Considering the functionality of interactive sound with regard to supporting walking activity, we can distinguish two types of approaches. First, interactive sound is used to optimize the user's body movements, thereby to contributing to the overall performance (in sports and rehabilitation). Second, it is used to support and deepen experiences that are specific to a particular setting, such as

[4] The term materialize is used by Hug (2008).

the walking experience in a game world or a pre-choreographed park. It should be noted that these experience-oriented approaches do not address the activity of an ordinary walker but rather the player's or the spectator's walking activity. In these applications, the aim is to support the experience of distinct walking aspects that are relevant to the overarching activity. That is to say, walking (and accordingly walking experience) is not considered and designed for as a self-contained activity but with regard to the overarching activity of playing a game, engaging with works of art or exploring the environment.

1.2 Research Question

> *"recognizing the central role of mediation in human thought and behavior may lead us to reframe the object of our work as 'computer-mediated activity,' in which the starring role goes to the activity itself rather than as 'human-computer interaction' in which the relationship between the user and a machine is the focal point of interest."* *(Nardi, 1995b, p.38)*

To sum up, while walking, our attention focus and behavior can be oriented towards various aspects, such as reaching the destination target, the environment we pass or our own thoughts. Whatever aspect occupies our attention, also predominates our walking experience. Quantified-self applications measure the user's walking behavior (e.g. counting steps, distance covered or energy expenditure) and provide feedback with regard to comparison and progress. These apps predominantly emphasize utilitarian aspects of walking and promote a mostly rationalized relationship with the activity. Experience-oriented applications focus on isolated walking aspects which are relevant to a particular setting and the experience of an overarching activity. In both approaches of designing interactive sound for walking, the activity is understood as a means to an end and not as a self-contained activity that is enjoyable in itself. This thesis sets out to explore an alternative design approach that focuses on walking as a self-contained activity. This perspective is distinctive as it takes walking itself as a starting point for understanding unfolding experiences and to inform the design of interactive sound. This direction follows flow theory and its concept that positive experiences emerge when a person is fully engaged with the activity at hand, and has an "intense experiential involvement in moment-to-moment activity." (Csikszentmihalyi, Abuhamdeh, and Nakamura, 2005, p.600). Therefore, this thesis is framed by the following exploratory research question:

> *How may we design interactive sound for the experience of walking as a self-contained activity?*

The question aims at understanding how interactive sound can be designed to strengthen the walker's experience of the activity process. In answering this overarching question two aspects are focused:

> *Which choices in design of interactive sound set the course for the walker's experience and what are the requirements to design for walking as a self-contained activity?*

> *How may we take choices in design of interactive sound to facilitate the experience of walking as a self-contained activity?*

This first sub-question aims for identifying the necessary requirements to design interactive sound with the aim to support walking as a self-contained activity. The second sub-question asks for appropriate design solutions to meet these requirements.

1.3 Contribution

The answers to the questions of this thesis contribute to understanding the design of interactive sound, and in particular the decisions that are critical when designing for everyday experiences. Moreover, they contribute to deepening our understanding for how the experience of everyday activities can be facilitated.

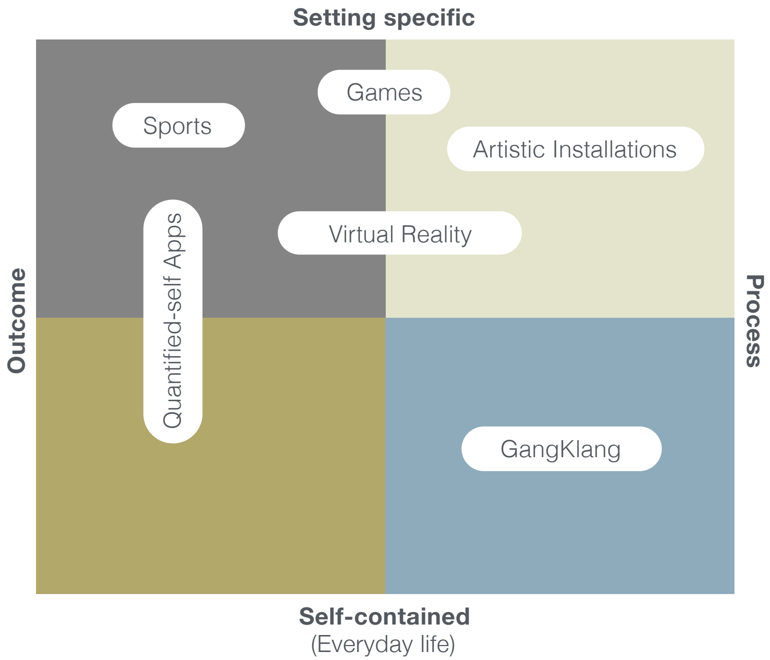


Figure 1.1: Illustration of the research gap this thesis aims to contribute to.

The potential of interactive sound to exert subtle influence on a person's experience opens up new possibilities to design for the experience of daily activities. Designing is about making decisions. In order to make purposeful decisions in design of interactive sound for everyday activities, an understanding is needed on how interactive sound is implemented and how these decisions provide a scaffold for the experience of the activity. This thesis contributes to the advance of design research by investigating this relationship. It does not work on a specific recipe for designing interactive sound and refrains from defining ultimate rules that will immutably result in promoting a specific experience. Rather, this thesis uses walking as an example of everyday activity to examine how decisions in design of interactive sound shape a lens for experiencing daily activities.

The findings are used to frame an alternative, activity-centered approach to design interactive sound for walking, named *GangKlang*[5]. *GangKlang* complements existing approaches of sonic interaction design by focusing on a specific relationship between the walking activity and sound. A relationship that does not transform walking into a different activity but rather re-emphasizes walking as a self-contained activity. This perspective highlights the ephemeral and unique moments of the activity and reprioritizes walking aspects in favor of momentary ones.

The main contributions of this thesis are two design solutions for instantiating the *GangKlang* concept in concrete design exemplars. To craft design solutions two perspectives were taken. The first perspective focuses on the walking process itself (see Chapter 4) and its result is *Walking-Phrases*: a process model of everyday walking that builds on the change of the walker's movements to derive contextual information. The second perspective focuses on designing a dynamic sonic gestalt (see Chapter 5) with the aim to facilitate the experience of walking as a self-contained activity. Its result is *GangKlang-Translations*: a framework to translate walking information into sonic events that organize in an overall sonic expression and strengthen the walker's experience of the walking process.

Parts of this dissertation and its results have already appeared in the following peer-reviewed publications:

Gait Biometrics in Interaction Design: A Work in Progress Report.

Hajinejad, Bogutzky, and Grüter, 2012: This conference paper presents the basic reasoning for conceiving a person's walking movements as an expression of objective and subjective conditions and for using walking data in design for mobile experiences (see Chapter 2). We further discuss

[5]The word GangKlang is a German portmanteau of gait and sound.

challenges in implementing gait feature extraction when using mobile devices.

GangKlang: Designing Walking Experiences.
Hajinejad, Grüter, Bogutzky, and Vatterrott, 2013: This conference paper presents the core of the *GangKlang* concept: designing a dynamic sonic gestalt with the aim to strengthen the walker's experience of the walking process and to facilitate the experience of walking as a self-contained activity (see Chapter 3).

Walking Phrases: modeling the walking process with respect to contextual conditions.
Hajinejad, Grüter, Licínio Roque, et al., 2016: This conference paper presents the theoretical basis for using walking movement data as a means to gather contextual information (see Chapter 4). The process-oriented study on situated walking movement is discussed together with the resulting walking model *Walking Phrases*.

GangKlang: Facilitating a Movement-oriented Walking Experience Through Sonic Interaction.
Hajinejad, Grüter, and Bogutzky, 2016: This conference paper presents the design of the *GangKlang* instance *Flow-Maschine* and its deployment in a study on walking experiences in everyday life (see Chapter 6). Drawing on interview data, results on sonified walking experiences are discussed.

Prototyping Sonic Interaction for Walking
Hajinejad, Grüter, and Licinio Roque, 2017: This conference paper presents a rapid prototyping system that allows non-expert designer to design interactive sounds for walking and to experience their design in the mobile context (see Chapter 5). The system provides constructs to translate walking information into sonic events that organize in an overall sonic gestalt.

Walking Phrases: Modeling the Walker's Context for Sonic Interaction Design

Hajinejad, Licinio Roque, and Grüter, 2017: This conference paper sets out contextual factors that are essential for mobile experiences and need to be considered in sonic interaction design. It presents the vocabulary of the walking model *Walking Phrases* in more detail and discusses how each of its elements can be used to adapt interactive sounds to the walker's context (see Chapter 4).

Embracing First-Person Perspectives in Soma-Based Design

Kristina Höök et al., 2018: In this journal paper, I contributed as a co-author. The paper argues for a specific design sensitivity in movement-based interaction design: a first-person perspective. To elaborate on the first-person perspective design exemplars are presented including on of the GangKlang instances, and the prototyping system resulting from the need to integrate a first-person perspective in the design process (see Chapter 5).

1.4 Research Design

The research subject of this thesis is situated at the intersection of Human-Computer Interaction and Interaction Design (IxD). It investigates the design of interactive sound for walking which involves interaction between a human and an interactive system. Designing interaction between human and computer is clearly a topic of HCI. However, designing for walking affords to consider the walker's physical movement and the mobile context. Moreover, a central concern of this thesis is to approach this design with a particular attention to the walker's experience. This experience-centered approach corresponds more closely to the perspective of Interaction Design which is specifically concerned with the aesthetic qualities of interaction.

An essential difference of HCI and IxD is the disciplinary background, i.e. the problems they deal with and the research methods that are used to address those problems. HCI starting point in the 1980's used to be the desktop computer and initially an engineering perspective was taken to solve well-structured problems. With the advent of computing technology in everyday life, interaction with computers is now embedded in a multi-faceted mesh of relationships including bodily, social and environmental issues. Today a wide variety of factors need to be considered in design of human-computer interaction and understanding the requirements has become a major challenge. This kind of problems are referred to as *wicked*, they are as Gaver describes it "complex enough that no correct solutions exist a priori and for which formulating the situation is integral to addressing it." (Gaver, 2012, p. 940).

In light of facing these under-structured problems, researchers in HCI have acknowledged the need to integrate design methods of IxD into the academic field. IxD which is rooted in a design discipline provides methods to address so called design problems. Logan and Smithers elaborate on design problems and specifically distinguish the design process from the process of solving search problems:

> *"We define a design problem as one in which either the objective to be achieved or the means of achieving it (or both) are initially only poorly defined."* *Logan and Smithers, 1993*

Research-through-design (RtD) is a method of inquiry in which the researcher engages in the activity of design to gain knowledge (Dalsgaard, 2010). It is important to note that in this research context the purpose of design practice is to contribute to the body of knowledge, not to realize a final product. Working on a particular design cases is a means of investigating research questions. My decision to use RtD was mainly moved by two considerations:

- RtD offers an effective way to gain insight into the design process in order to understand how the abstract idea of an intended walking experience is operationalized into particular implementation of interactive sound. This kind of understanding is about "how ideas and concepts were embedded in the designs." (Wiberg, 2014).

- RtD prevents taking an isolated point of view on single aspects when investigating interdependencies.

My objectives in using a Research-through-Design approach are:

- to reveal interdependencies between the implemented components of interactive sound, the walker's activity and the walking experience,
- and to ultimately work out a framework for orienting the design of interactive sound towards the walker's experience.

My particular way of using the RTD approach to answer the research questions of this thesis is by prototyping mobile applications that enable interactive sound for walking and studying the user's sonified walking experiences. The research activities are presented in Figure 1.2 in their order of occurrence within the process. The overall process is divided into seven cycles.

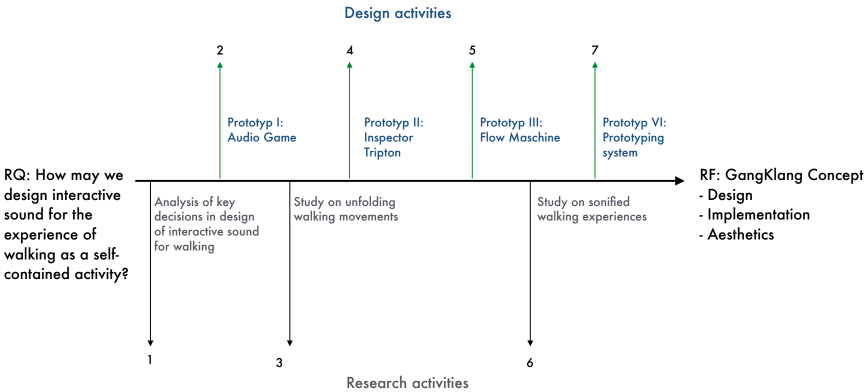


Figure 1.2: Illustration of the research process of this thesis (Adapted from (Dalsgaard, 2010)).

Design cycles are concerned with design and implementation of mobile applications and are illustrated above the timeline (2,4,5,7). In cycle 2,4 and 5, prototypes of interactive sound for walking were designed and implemented in three different design cases (Prototype I, II, III). In cycle 7 a rapid prototyping system was implemented that integrates the foregoing findings and enables non-expert users to design interactive sound for walking and to experience their design in the real-world context.

Research cycles describe studies which were conducted and are illustrated below the timeline (1,3,6). In cycle 1, I analyzed key decision in design of interactive sound for walking. In cycle 3, I employed Prototype I to study walking movements as they unfold in changing conditions and to develop a walking model. In cycle 6, I employed Prototype III to study how interactive sound bears on the walkers' experiences in daily life context.

1.5 Research Subject and Terms

This research is allocated in the interdisciplinary field of sonic interaction design (SID) which explores possibilities of designing human-computer interactions with the "active, embodied, and emotionally engaging uses of sound." (Franinović and Serafin, 2013, p.X). Sonic interaction is used as an umbrella term to refer to any kind of technologically enabled mapping from user action to sound or as Caramiaux et al. (2015, p.3943) put it "continuous relationship between user actions and sound, mediated by some technology."

The starting point and core of this research endeavor is to investigate sonic interactions as a medium for the walker's experience. From this standpoint, sonic interactions play a functional role in design for walking experiences. Their function is to provide desirable conditions for the walker's experience. Thus, sonic interactions are designed as mediators and are not intended to become the motive of the walking activity itself. To emphasize the focus of my exploration on the instrumental role of sonic interaction, I draw on Karen Collins notion of "interactive audio" and use the term *interactive sound* throughout this thesis. The term interactive audio was introduced by Karen Collins in the context of "non-linear, variable elements in the sonic aspect of gameplay" (Collins, 2009, p.5) and defined as: "Interactive audio refers to sound events directly triggered by the player, affected by the player's input device (controller, joystick, and so on)." (Collins, 2009). Throughout this thesis, the term *interactive sound* is used in a similar manner to refer to sound events that are triggered and modified in response to the walker's activity, by means of an interactive system. By walking, the user triggers sonic events that form a sonic expression by the sequence of consecutive steps. The term interactive sonic expression is used to describe the overall soundscape that evolves through the interplay of a series of interactive and adaptive sounds. The soundscape concept and its use in this the design explorations of this thesis will be explained in more detail in Chapter 5.

In HCI research literature, two terms are commonly used to describe the technologically enabled coupling between the user's activity and sound: *mapping* and *sonification*. Most generally, the term mapping refers to the coupling of any two matters in HCI. Focusing on interaction design, Preece provides the following definition of the term mapping "refers to the relationship between controls and their effects in the world. Nearly all artifacts need some kind of mapping between controls and effects" (Preece et al. 2002, p.23). The term sonification and interactive sonification [6] are more specifically concerned with mapping any kind of data structures into structures perceptible by the ear (Dayé, A. d. Campo, and M. E. d. Campo, 2006). Arguing for a clear terminology, Hermann defines sonification as: "Sonification refers to the technique and the process, so basically it refers to the algorithm that is at work between the data, the user and the resulting sound. Often, and with equal right, the resulting sounds are called sonifications. Algorithm means a set of clear rules, independent of whether it is implemented on a computer or any other way." (Thomas Hermann, 2008, p.3).

However, there is a degree of uncertainty around the term sonification as some authors use the term more specifically in the context of data analysis. For instance, Hermann characterizes sonification from a scientific perspective and imposes special conditions on the rules of sonification such as: "The sonification is reproducible: given the same data and identical interactions (or triggers) the

[6] Interactive sonification is defined by Hermann and Hunt as "the discipline of data exploration by interactively manipulating the data's transformation into sound" (T. Hermann and Hunt, 2004, p.1)

resulting sound has to be structurally identical." (ibid., p.2).

In contrast to this scientific perspective, in artistic projects and experience-oriented applications, it is mainly the aesthetic effect that is in the focus of design. In this thesis, I use the term *translation* to refer to the algorithms and rules between data and sound. The aim is to avoid the connotations of analysis with the term sonification and to emphasize the effect of the mapping design instead.

1.6 Outline

This thesis takes the following steps to present the research and design activities (see Figure 1.3):

Chapter 2 outlines current challenges associated with the design of mobile everyday activities. The main focus is on the interdependence of the analytically separated dimensions of walking (cognition, spatiality and physicality). The activity theory is presented as a framework with concepts to consider these interdependencies and to approach the walker's experiences on the basis of the activity process.

Chapter 3 compares existing design examples that use interactive sound to support different walking aspects. On the basis of this analysis, two fundamental pillars of designing interactive sound are identified as being decisive for how walking is promoted. Conclusively, the requirements are outlined when designing with the purpose to promote walking as a self-contained activity. Design solutions to meet these requirements are then addressed in the following chapters.

Chapter 4 addresses the first of the above pillars and explores how the walker's unfolding process can be modeled in the absence of a predefined setting. A study is presented that explores the walker's movement as an individual embodied expression of context. The study findings are used to model the unfolding walking process (*Walking Phrases*). Further, the model's application in design of interactive sound is discussed.

Chapter 5 investigates the second pillar, focusing on how to translate the walker's process data into a dynamic sonic expression. Three design cases of interactive sound for walking are presented. The insights gained by prototyping are presented in the framework *GangKlang-Translations* which includes a strategy for strengthening the walker's experience of the activity process itself.

Chapter 6 presents the evaluation of the design solutions for *GangKlang*. Towards this goal, a comparative study is conducted that explores how the interactive sonic expression of Prototype III bear's on the walker's experience in everyday life.

Chapter 7 revisits the research questions and summarizes the results of the thesis. The main findings contributing to design for everyday activities are discussed and implications for future research are given.

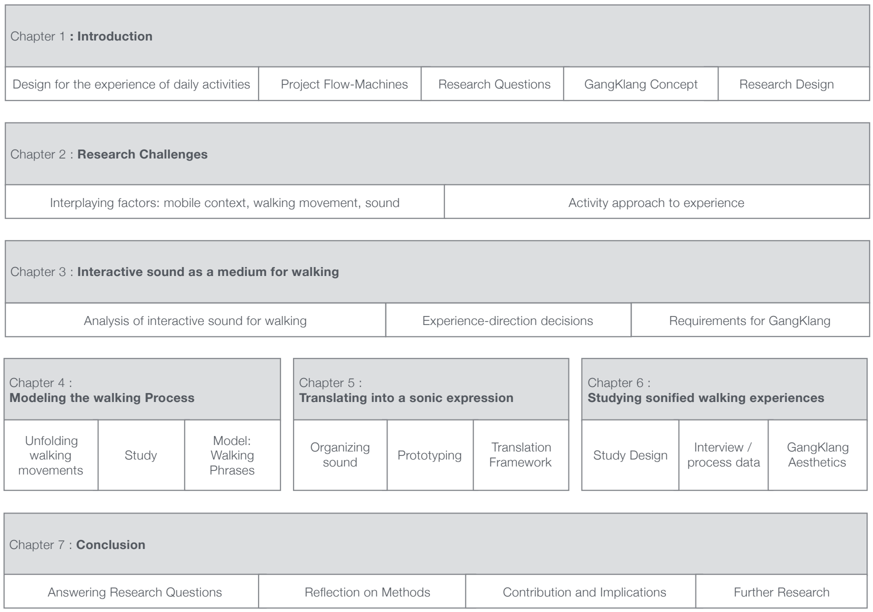


Figure 1.3: Schematic illustration of the thesis structure.

2 | Research Challenges and Approach

> *"It is in this bringing together – holism if you like – that experience has its power to critique theories that differentiate and research methods that separate and reduce. The vitality is lost when the threads of experience are picked apart for analysis or experimentation."*
>
> — McCarthy and Wright, 2010, p.1

A vital characteristic of my investigation is that I focus on the walker's experience to study and inform the design of interactive sound. With the notion of experience an holistic approach to interaction design is taken that opposes the dissecting tradition of the engineering sciences.

What is particularly challenging in designing for the walker's experience is to understand and model the process of its emergence and consider the interplaying factors that play a role. These factors include, among others, the mobile context, the walker's body movement and the experience of sound. In this chapter, I first illustrate the influence of these factors on the walker's experience and in doing so introduce issues that are investigated in different domains of HCI: mobile interaction, movement-based and sonic interaction design. I then elaborate on the activity-centered account on experience and how it provides a framework to explain these factors in their inner connection.

2.1 Mobile context

Knowing the changing circumstances and how they affect the walker's activity process and experiences is a critical point in order to provide interactive sounds that are supportive to a person in a current situation. Factors that have been highlighted for experiences in the mobile context are site-specific characteristics and the user's cognitive load (Marshall and Tennent, 2013).

Being on the move our behavior and experiences are influenced by all kind of changes, traffic, people, signs and noises (Sá, 2011). Ordinary walking is a multitasking activity in which the walker's attention is distributed across various processes: coordinating walking movement, observing traffic, and sorting thoughts, to name a few. The changing conditions along the walking process can be more or less demanding, require more or less attention and as such impose more or less load on the walker's cognitive system. Accordingly, the walker's attention resources and receptivity for processing interactive sound varies.

Today, the sensing capabilities of smartphones (inertial accelerometers, gyroscopes and GPS units) offer a wide range of possibilities to collect objective data on structures and processes that surround the walker's situation, such as location and time (context-aware computing (Schmidt, 2000). However, not all changes are relevant to the individual walker and his or her subjective experience. Walking situations that are similar from an objective point of view (such as geoposition, time of day, walking subject) have a different effect on the individual and do not result in the same walking experience. It should be noted that each situation is unique and that potential factors only become influencing conditions through the actor. Svanaes highlights this consideration as follows: "the term context-aware technology is an absurdity as context is not a property of the physical world, but rather the horizon within which a user makes sense of the world. Context is not a property of the physical world, but rather the horizon within which a user makes sense of the world." (Svanaes, 2001, p.398). But how can we model the unfolding conditions of the individual walker in design?

2.2 Walking movement

An essential dimension of the walker's experience is the walker's body movement. Alongside the design and development of movement-based interfaces, scholars in HCI have started to acknowledge and study the relation between body movement and experience. The pertinent theme of embodiment in HCI is that the world reveals itself to the humans through their body and bodily capabilities and "our bodies and active bodily experiences inevitably shape how we perceive, feel, and think." (Hornecker, 2011, p.22).

A common model of the walker's movement process is to describe it on a biomechanical level, by the cyclic movement of two consecutive steps, referred to as a gait cycle (Best and Begg, 2006). Studies have demonstrated that that walking properties are influenced by external conditions such as sociocultural factors, traffic intensity or vegetation (Bornstein, 1979; Franěk, 2013). At the same time, it has been shown that characteristics of the gait cycle reveal information on walkers internal states, as for example arm swing and stride length change according to walker's emotional state (Montepare, Goldstein, and Clausen, 1987).

These findings demonstrate the interrelationship between the walker's body movement and conditions that organize the walking process. This interrelationship in turn provides new opportunities for design. It implies that the walker's body movement can be used to capture individual walking conditions. At the same time, it points out that the walker's movements can be used for access to the walker's experiences. So how do sonic conditions affect the walker's movements and experiences?

2.3 Sound

As was pointed out in the introduction, sound and body movement are highly connected. Walking in daily life is not a matter of motor capabilities only, but rather the result of the interplay of locomotor pattern and sensory information. While walking, we create sounds with each step that we take, for instance when we hit the ground with our shoes, by rolling of the foot on a gravel path or by the friction of our cloth as we move our legs and arms. The acoustical properties of these sounds are the result of the involved materials (shoes sole, floor) and the dynamic properties of the movement itself and inform the listener about the conditions prevailing. Or to put it more generally, "sound provides information about an interaction of materials at a location in an environment." (Gaver, 1993, p.5). These sounds are an essential source of information through which we coordinate our movements. Visell et al. (2009) provide an overview on multidisciplinary knowledge on how footstep sounds reflect walking characteristics. Using this knowledge, various experimental studies have investigated how confronting walkers with different auditory stimuli may modify their gait properties. Different features of sound have been demonstrated to have an effect on particular gait properties. The organization of motor behavior can be entrained to auditory rhythm (Thaut et al., 1999). This relationship is investigated in e.g. in sports (Karageorghis and Priest, 2012) and used as a means to regulate and optimize the running performance (Bauer and Kratschmar, 2015; Rubisch et al., 2010) and walking cadence (Franěk, Noorden, and Režný, 2014). In addition to time-entrainment, expressive musical features can influence on the walker's stride length (Leman et al., 2013).

Only recently, the relation between sonic feedback, walker's movement characteristics and felt experiences has been investigated. Tajadura-Jiménez et al. (2015) used sonic augmentation to alter the frequency of the walker's natural footstep. Their study findings confirm that walker's gait, perception of body weight and emotional state can be positively affected.

At the same time that sound acts upon a person's body movement, so do a person's activity and its contextual conditions influence the perception of sound. The particular context within which sound is perceived can be decisive for the sonic properties that the listener focuses on and hence color the perception and interpretation of sound. Embodied approaches to listening point out that perception of sound is "dependent on the way the sound is involved in the situation and how we see its relevance to the context of interaction" (Tuuri and Eerola, 2012, p.1). Moreover, the listener's body movement has an influence on the way sound is perceived (Maes et al., 2014).

Altogether, research findings in mobile interaction, movement-based and sonic interaction design emphasize the interplay of environmental and social conditions, the walker's body movement and the experience of sound. Considering this very interrelatedness in design of interactive sound is a specific objective and challenge of my research project. In the next section, I present activity theory as a theoretical framework. I elaborate on how principles of the Activity Theory can be used to meet the challenges set out above.

2.4 Activity Theory

> *"Those who deliberately look for experience, find emptiness. But let a person immerse himself in action - a deep, real-life action - and he will be flooded with experience."*
>
> *(Kaptelinin and Nardi, 2012, p.48)*

Activity Theory is a conceptual system encompassing a set of interrelated principles developed by Alexey Leontiev. It has been proposed as a theoretical framework for HCI in the late 1980s (S. Bødker, 1989), recognized for being particularly helpful to understand and consider the context of everyday activities (Nardi, 1995a) and to design for mobile interaction (Grüter, 2008; Grüter, Hajinejad, and Sheptykin, 2014). In my understanding of Leontiev's Activity

Theory, I mainly draw on the work of Victor Kaptelinin and Bonnie Nardi. The authors formulate in their book *Activity Theory in HCI* (Kaptelinin and Nardi, 2012) basic concepts and principles of Leontiev's activity approach with regard to HCI.

Activity Theory frames interactive technologies as "mediating tools" that allow people to accomplish activities. This perspective emphasizes that interacting with a computational system is not a self-contained activity and as Kaptelinin and Nardi put it "people are not interacting with computers: they interact with the world through computers." (ibid., p.6). With this account interactive systems have both "an enabling and constraining function." (Kaptelinin, Kuutti, and Bannon, 1995, p.192). That is, "On the one hand, tools expand our possibilities to manipulate and transform different objects, but on the other hand the object is perceived and manipulated not "as such" but within the limitations set by the tool." (ibid., p.192)

In the following, I discuss firstly, the basic concept of activity as it relates to subjective experiences. I particularly focus on principles of Leontiev's approach that focus on the relation between human action and conscious experience. The understanding of human action as a unit of psychological analysis becomes particularly useful in the context of experience-oriented interaction design and body-based interfaces. Then secondly, I describe the principle of the hierarchical structure of activity as it provides a descriptive tool for understanding the inner connection between the above mentioned interplaying factors.

2.4.1 Subjective experiences

AT is based on the understanding that human action and cognition are not separated and has gained in importance as a post- cognitivist approach in HCI (Kaptelinin, Nardi, et al., 2003). A basic principle of Leontiev's activity approach is the "unity and inseparability of consciousness and activity" that was first formulated by Rubinshtein in 1946. According to Rubinshtein "human conscious experience and human acting in the world, the internal and the external, are closely interconnected and mutually determine one another." (Kaptelinin and Nardi, 2012, p.14). Building on this fundamental understanding, Leontiev developed the concept of *activity*. The notion of activity provides an account that integrates a person's external processes and internal processes. From this activity theoretical perspective, subjective mental processes are embedded within a person's activity. Thus, according to Leontiev, a person's activity can be used as an access point to understand his or her subjective experiences:

> *"... it is external activity that unlocks the circle of internal mental processes, that opens it up to the objective world."*
>
> *(Leontyev, 1977, p.5)*

2.4.2 Activity structure

Leontiev provides an analytical schema to describe the interplay between physical and mental processes in an activity. In this schema a person's activity is organized in a dynamic hierarchical structure of three dynamic layers: activity, actions, operations. All layers describe the same process, however segmenting it into larger or smaller sequences. For instance, a person's activity can be described as making a step, walking down a street, or navigating from home to a friend's place. The upmost layer, called activity layer, considers a person's process with regard to a motive that drives a subject to become active. For instance, what drives a person to navigate might be to get in touch with other people. The motive of an activity is "the object that the subject ultimately needs to attain." (Kaptelinin and Nardi, 2012, p.26).

To fulfill this need, the subject undertakes partial steps. These partial steps are called actions and are assigned to the middle layer of the hierarchical structure. Each of these actions are associated with a specific goal. The distinguishing feature of actions is that the subject is aware of its goal:

> *"We call a process an action if it is subordinated to the representation of the result that must be attained, that is, if it is subordinated to a conscious purpose."*
>
> *(Leontyev, 1977, p.99)*

Taken together, the sum of all actions will lead the subject to fulfill the need. In our example turning into a particular street may be a partial step, one of many actions to fulfill our need to visit a friend. Each action, in their turn, can be segmented into a number of smaller sequences, called operations. Operations form the lowest hierarchical layer of the activity framework. In our example, the action of walking down a street can be subdivided into smaller sequences of consecutive steps. During each operation the same walking movement is performed, however modified with regard to given conditions. For instance, the person may walk more slowly as the street gets busy, or the walker accelerates to cross a side street. What differentiates sequences on the action level from those on the operation level is whether they are carried out consciously or automatically. Kaptelinin et al. describe this transition as follows:

> *"Moving down the hierarchy of actions we eventually cross the border between conscious and automatic processes."*
>
> *Kaptelinin, Kuutti, and Bannon, 1995, p.193*

2.5 Discussion

> *"Activity theory provides a coherent account for processes at various levels of acting in the world."*
>
> *Kaptelinin and Nardi, 2012, p.26*

In this chapter, I have discussed mobile conditions, body movement and sound as influencing factors for the walker's experiences and emphasized that they need to be considered in design of interactive sound. Moreover, modelling the factors that become effective for the individual walker is a specific challenge to design for daily life. A promising approach to tackle this challenge is to incorporate the analysis of body movement, such as it is used in embodied interaction design.

Further, I have outlined the challenge to account for the interrelationship of the influencing factors. Here, the activity concept and its notion of experience is informative. On the whole, the activity approach takes a process-oriented framework to investigate everyday experiences. Activity refers to the unit that results from the organization and the interplay of the individual factors. According to this perspective the activity itself is the context from which to understand emerging experiences. Leontiev's activity structure provides a basis for the inner connection of the different external and internal processes that play a role for the walker's experiences, such as the changing environmental conditions and the varying cognitive resources. This way, the activity structure can be used to organize and relate the various type of information on the walker's activity.

3 | Interactive Sound as a Medium for Walking

> *"Mapping action to sound has emerged as one of the most important research topics in the development of digital musical instruments [...] and in general human-computer interaction"*
>
> — Jensenius, 2008, p.2

As laid out in the introduction, current walking applications use interactive sound to emphasize different aspects of the activity. This chapter takes a closer look at interactive sound as a medium for the walker's experience. *What are key decisions in design of interactive sound that give direction to the walker's experience?*

In this chapter, these key decisions and how they contribute to the user's walking experience are identified by analysis of existing examples of interactive sound for walking. Building on this, requirements are formulated for the *GangKlang* approach that aims to facilitate the experience of walking as a self-contained activity.

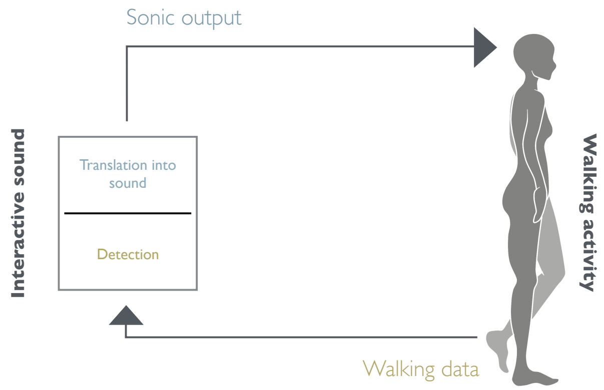


Figure 3.1: Illustration of main components of interactive sound in the feedback loop.

3.1 Interactive Sound as a Means of Facilitation

Interactive sound for walking is enabled by interactive technology that interweaves the user's walking activity with sound. To realize interactive sound for walking, two technical components have to be designed and integrated: one component that detects relevant information on the walker's activity and another component that utilizes this information to generate sonic output (see Figure 3.1). How does designing the two components set the path for a walking aspect to be supported? I investigate this question by comparing concrete design examples. All examples implement the two components of interactive sound, however they are tailored to facilitate different aspects: the walker's engagement with the environment, the walker's navigation process, the walker's body movement.

I structure my analysis by focusing on the following questions and related design choices:

- For which walking setting (application context) is the interactive sound designed, and which factors are considered essential for this context?
- What kind of activity model is used and what walking information is

detected to trigger and modify the sonic outcome?

- Which sonic parameters are selected to dynamically adapt in relation to the walker's activity and how is this supposed to affect the walker's experience?

The result of the analysis is a map of critical design choices, their interdependencies and how they influence the walker's experience of the activity. The chapter ends with implications for the design of *GangKlang* instances.

3.1.1 Facilitating engagement with the environment

In design of *Locative soundtracks* (as introduced by Hazzard et al., 2015) interactive sounds are used to enhance the experience of walking within a curated physical space. Walking in this particular context is named *locative walking* and describes for instance walking while visiting a sculpture park, or playing a location-based game. Locative walking requires that a set of point of interests (POIs) within a predefined space have been defined (e.g. by the game designer) which the walker explores and engages with without, however, following a specific route: "locative experiences that have an ingrained purpose that take users on a journey in, through and out of engagement with a range of locales and points of interest." (Hazzard, 2016, p.49). The most important aspect of locative walking is the encounter and engagement of the walker with POIs. In accordance with this aspect, the relevant information that is detected is the user's geographical position in relation to the predefined POIs. The process of locative walking is modeled as a sequence of phases that describe the walker's spatial relationship to the POIs including approaching, engaging and moving away from them. This walking information is used to dynamically arrange and modify a soundtrack that the walker can hear while strolling within the curated space. The musical attributes of the soundtrack dynamically change along the detected walking phases and the current POI. The intended aesthetic is to deepen the walker's experience of tension and relief while moving from one POI to the next. Towards this goal, pre-composed musical phrases are rearranged and layered in response to the walker's locative movement. This way, the soundtrack addresses the walker on an emotional level by attuning his or her mood to the atmosphere of the POI and thereby focusing the walker's attention to it.

Situated soundscapes address a similar walking practice. Situated soundscape is a term used by Paterson and Conway (2013) to denominate a number of artistic installations where interactive sound is used to facilitate walkers encountering experiences with the environment. In a situated soundscape there is no need for a curated space limiting the walking area and points of interest don't need to be individually predefined by their specific geographic position. Instead, POIs are defined through specific environmental attributes that are detected by employing corresponding sensors. In *Electric Walks* (Kubisch, 2004) for instance, POIs are created by making electrical currents audible through a specific form of headphones. This way, naturally inaudible things and places become perceivable for the walker and mundane and unnoticed spaces turn into places of interest. Walking in this context is a practice of perceiving and interacting with newly perceivable sound sources. Exploring these places, approaching, engaging and moving away from them is at the center of the walking experience. However, in situated soundscapes not only objects within the environment trigger interactive sound and thereby become worth exploring for the walker. In *Sonic City* (Gaye, Mazé, and Holmquist, 2003), for instance the walker's proximity to others is used to modify interactive sound, as well as walking events such as starting and stopping and walking properties such as pace are made audible. Here, interactive sound is used to encourage the exploration of unappreciated spaces and thereby provides new incentives for walking. The relevant properties of the sound source are communicated through the specific sonic attributes. In addition to musical structures, noise and foley are used to equip the newly audible source with a certain materiality. Moreover, the walker is encouraged to explore the own body movement and interactive sound is used to direct attention outwards and also towards the self.

3.1.2 Facilitating navigation

To support the walker's wayfinding process in everyday life interactive sounds are incorporated in *navigation guides*. As in the example of situated soundscapes, interactive sound is used in navigation guides to provide walkers with an awareness of their own location in relation to a place in the environment. However in this setting, the target place is defined by the individual walker. Here, emphasis is put on effectively navigating to a destination rather than drifting and exploring the environment. Thus, the walking process is modeled as a spatial movement from a starting point A to a target destination B. Alongside this process, information on the walker's position and orientation is detected and used to change attributes of interactive sound in order to direct walkers into a specific direction. In addition to distance, the walking model includes the walker's orientation. To allow the walker to navigate effectively it is important that he or she gets a clear sense of the dynamic sonic parameters and understands how they are related to the own orientation. For this purpose, sonic parameters are chosen with regard to our daily experiences of spatializing effects of sound (Liljedahl and Lindberg, 2011). For instance, information on the distance to the destination is used to change the volume of interactive sound; information on the direction of the destination is used to turn the sound louder on the right resp. the left ear; or depending on whether the destination is in front or behind the walker to change the sound to be more (in the back) or less (in the front) muffled (Holland and Morse, 2001).

3.1.3 Facilitating body movement

Mobile fitness applications that aim to support runners in optimizing their performance use interactive sound for training purposes. Training guides address the activity of running however their use of interactive sound can be applied to the walking activity too. Bauer and Kratschmar (2015) provide an overview on existing training guides. In this training context interactive sound is used to regulate the physical strain and accordingly the training intensity. Here, the conditions that are relevant are the runner's (resp. walker's) body movement and the activity is modeled as a process of physical effort. These applications collect information on pace, physical condition (heart rate) and training phases. Although body movement information is used to trigger adaptive music, the primary intention is not to expand the walker's awareness of their body but rather to influence their movement towards a desired tempo. In accordance with a target-pace music is adjusted by changing its tempo or volume to push the runner towards a faster pace or to slow him or her down.

Applications that use interactive sound to address the walker's body movement are developed in the context of research studies. These experimental studies take an isolated view on the interplay between the walker's body movement and sonic parameters and ignore conditions of the mobile context. In an early study, Bresin et al. (2010) used interactive technology to augment the walker's footsteps with sound and thereby aurally simulate different ground surfaces. Their findings indicate that walkers change their walking pattern according to the sonic feedback they trigger with their footsteps.

Tajadura-Jiménez et al. (2015) used interactive sound to alter walkers' perception of their own body weight. In this case walking is understood as a form of self-perception, as the sounds we produce through our steps hitting the ground, inform us on our body and physical appearance. The researchers modified the step sounds of the walker in real-time so that the walker would actually hear a lighter or heavier body moving. This way they could influence how walkers perceived their own body weight as well as their walking manner.

3.2 Synopsis

In the examples above the walker's activity is considered in quite different ways. Depending on the particular setting within which the walking activity takes place, different purposes are attributed to the activity. This purpose may be experience-oriented such as exploring and engaging with objects and places in the environment, as in the example of locative soundtracks and situated soundscapes. Or this purpose may be performance-oriented such as reaching a target destination or training the body. In any case the attributed purpose serves as the top-level reference point. On the basis of this reference point, factors that are essential for the walker's experience i.e., for the walker's performance are selected.

In the case of locative walking, the reference point is the walker's engagement with predefined points of interest. Accordingly, information on distance to objects is selected as crucial for the walker's experience. Whereas essential factors in training guides are training phases and physical effort. In the interactive system the detection component is used to capture and monitor the state and development of these factors using data on the walker's geolocation, spatial orientation or cadence. The result is a data-based process model of the walker's activity. The examples above model the walker's activity process at different scales. For instance, focusing on a more gross scale on locative changes (locative soundtracks) or on more fine-grained scale on single walking steps.

Another major choice concerns how changes of these factors shall be experienced. The designer may use from a range of possibilities to convey information by means of sound (Tuuri and Eerola, 2012). Like the decision on the walking model itself, this choice is made with regard to the walking setting. In the case of *locative walking* within a sculpture park, the designer targets on the walker's emotional and narrative engagement and wants that changes in the walker's distance to points of interest influence the walker's emotions. To evoke the experience of tension and relief as the walker moves from one POI to the next, pre-composed musical phrases are rearranged and layered in response to the walker's behavior. Here, musical structures such as key centers, harmony and rhythm are used to change along the walker's activity. This strategy draws on findings that sonic structures, such as timbre and melodic contour, convey affective information (Hailstone et al., 2009) and musical attributes can be used to attune the walker's mood to affective qualities.

Situated soundscapes address the walker's perception to influence the walker's sense of place and as a means to support engagement with the environment and to facilitate immersion. "By augmenting an urban space, places and activities that were previously viewed as mundane become reinterpreted, revealing details and experiences that were unseen, thereby providing a rich and new encounter of this new world." (Paterson and Conway, 2014). Here, sonic attributes are used to convey material properties of unnoticed objects and processes and to increase the walker's immersion into the environment. Navigation guides focus on the walker's spatial awareness. Accordingly, spatializing attributes such as volume, panning are selected to be modified by the walker's activity. The focus of training guides is on influencing the runner's resp. walker's body movement. Here, the movement inducing effects of sound are used as a means to guide and optimize walking movement. Different features of sound have been demonstrated to have an effect on the frequency of the walker's natural footstep.

App	Walking Purpose	Walking Data	Functionality of sound
Locative soundtrack	Engaging with POIs	Change of location in relation to POIs	To attune emotionally
Situated soundscapes	Explore things and processes	Location change in relation to POIs, Change of movement	To materialize object and processes
Navigation guides	Navigate to Destination	Location and orientation change in relation to destination	To facilitate spatial orientation
Training guides	Enhance physical fitness	Change of pace	To optimize body movement

Table 3.1: Overview on the walking activity in the three design cases.

3.3 Experience-directing Pillars

Let us return to the question with which we started: *how do decisions in interactive sound design give direction to the walker's experience?* From the analysis above, we can say that there are generally two translation tasks through which designers give direction to the walker's experience.

The first translation task can be referred to as modeling: the process of translating the walker's activity into a process model. The outcome of this decision is a process model. In the examples above, this translation process includes attributing a setting-specific purpose to the walker's activity. What needs to be noted here is that this attributed purpose is not what actually motivates the individual walker but what the designer designates to be the most important aspect within a particular walking setting. Based on this purpose the designer makes a decision on context factors that are essential for the walker's experience or for the walker's performance. These factors are then used to create a model of the walking process. In an interactive sound system, the data set that is tracked by the detection component reflects the aspect that the designer has chosen to be most important for the walker's experience of the activity. It is here that designer's decide which aspect (for instance the process of navigation or body movement) is specifically important for the walker's experience in this particular setting. Here it is important to keep in mind that the particular set of walking information limits the application's view on the walking activity to a specific aspect while other aspects remain unconsidered.

The second translation task is the design of a dynamic sonic expression: the process of translating walking data and its change into sonic material and its modulating parameters. Designing a sonic expression includes selecting sonic material and a set of parameters. This sonic expression provides the walker with a particular way to interpret changes along the process. All examples make use of the walker's auditory channel to influence the walker's experience. However, they use different sonic parameters and thereby address the walker's experience on different ways including emotion, perception and body movement. Again, the decisions are strongly determined by the setting and purpose of the walking activity. Depending on the purpose, the sound parameters (and their according effects) are selected.

Metaphorically speaking, we can say that the designer of interactive sound shapes a specific kind of lens for the walker's experience. This lens gives direction to the walker's experience by accentuating selected aspects of the activity and provides the walker with a particular way to interpret changes of this aspect. Concerning interdependencies, we can see that in all cases the particular setting decisively influences the choice of the aspect that is accentuated. Deriving from this choice, decisions are made regarding the selection of walking data to be tracked and dynamic sonic parameters that are mapped to it.

3.4 Considerations for GangKlang

The analysis above provides a basic understanding for how interactive sound is designed to direct the walker's experience towards selected aspects of the activity. They use the walking setting as a starting point and main reference framework to design interactive sound for the walker's experience. The walker's activity is considered only in its function within this setting. Accordingly, the process model that is incorporated in the interactive system considers a setting-specific aspect of the walker's activity only. In this section, I outline the cornerstones of the concept *GangKlang* by contrasting this activity-centered approach to the examples above and discussing challenges that are related to it.

3.4.1 Requirements

The walking purpose of existing strategies require a specific context such as predefined POI in a curated space to walk in (locative soundtrack, training guides) or they provide new motives for walking (situated soundscapes). Regarding a design strategy to support the walking activity, we could say that it is not necessary to introduce new walking opportunities, practices and spaces but to enhance the existing everyday walking practices. Navigation guides are usable in daily life; however orientation does not matter on routes that we walk frequently (supermarket, work, friends). To design for everyday walking experiences, a strategy is needed that builds on the walker's natural activity.

In the examples above relevant factors for the walker's experience are derived from the particular setting and the attributed walking purpose. Based on the predefined setting, walking information is selected and used to model the walker's activity. Based on this walking model, the sonic expression is designed to reflect a predefined process of activity. In daily life, all of these factors (and the processes modeled from) are interrelated and have a role to play in the walker's experience. Here, the individual and subjective conditions are decisive for which factors becomes predominant for the walker's experience. For example, the process of encountering objects and places might be specifically important for the walker's experience in a curated sculpture park, but this process is also part of ordinary walking. A person walking from office to home will pass various places and objects that are meaningful to him or her and that will affect this person's walking experience. Likewise, do other processes such as varying bodily effort and navigation to a target destination influence a person's walking experience in daily life. Thus, prescriptive approaches that predefine factors that are important for the walker's experience are not sufficient to design for walking in daily life.

To design for everyday walking, a model is needed that considers individual emerging conditions and processes that become effective for the walker's experience. In order to be applicable in the various scenarios of everyday walking, a model is needed that captures characteristics that are fundamental to walking experiences and the unfolding walking process itself, rather than characteristics of setting-specific aspects of walking. The requirements for the sonic expression need to comply with the activity structure. It needs to have a structure that considers the internal context of the different aspects and allows the walker to experience the emergence of these aspects along the walking

Figure 3.2: Scenario of using interactive sound in everyday life.

process.

As outlined in the previous chapters, this thesis aims for an approach that designs for walking as a self-contained activity. This perspective, is different from the approaches above regarding the following:

- Prescriptive approaches start with a defined setting and motivation and focus on the functionality of walking to model the walker's activity. In contrast, the *GangKlang* concept takes the unfolding walking process as a starting point for design.
- Prescriptive approaches predefine contextual factors on the basis of the walking setting. *GangKlang* derives contextual factors from the walking process and thus these factors are only considered in their effect on the walker's activity.
- Prescriptive approaches design a sonic expression to support the walker's experience of change in a setting-specific aspect or facilitate the achievement of goals. In *GangKlang*, the sonic expression is designed to foreground the unfolding walking process, its emergence, stability and decay.

The next chapters address the requirements of the *GangKlang* concept and draw up solutions for modelling in Chapter 4 and translation into a sonic expression in Chapter 5. The aesthetics of *GangKlang* instances are studied and discussed in Chapter 6.

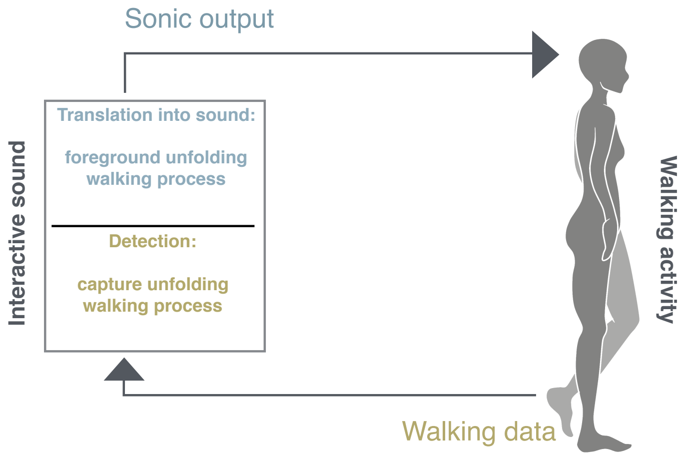


Figure 3.3: GangKlang Requirements applied to components of interactive sound.

3.4.2 Iterative design of GangKlang solutions

As explained in Section 1.4, this thesis takes a research-through-design approach. I designed prototypes of interactive sound for walking for different design cases with the purpose to draw up solutions for modelling and sonic translation that follow the requirements of the *GangKlang* approach. In this iterative approach, the design solutions have successively been refined.

The design cases have developed in context of the research project Flow-Machines and the prototypes were implemented together with members of the project. In particular, my colleague Simon Bogutzky and the student assistants Jan Schrader and Phillip Marsch developed detection algorithms to gather and analyze the user's walking activity. My contribution to the design cases and related prototypes includes:

- Conception of (sonic) interaction mechanics including a walking model
- Implementation of sound processing algorithms and constructs to translate walking information into sonic output
- Methodology and evaluation

For a better understanding of the following chapters, this section ends with presenting the basic framework of the technical system that was used to implement interactive sound for walking.

3.4.3 Technical framework

All prototypes were implemented using the iPhone 4S. The basic architecture of the different applications can be described with four basic components: feature extraction, App Controller, Audio Controller and Database.

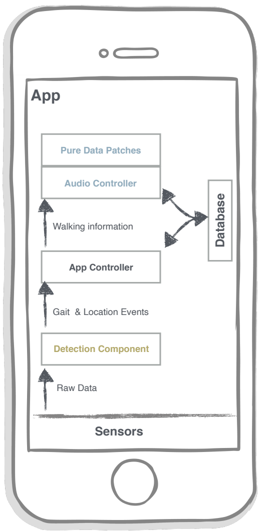


Figure 3.4: Conceptual illustration of the technical architecture for implementing prototypes of interactive sound.

App Controller is the central component that coordinates the cooperation of other components. This component includes functionalities to display the necessary screens for each application. The App controller is also the interface between the two components detection and audio controller. Here, all walking information is collected to delegate them to corresponding functions of the Audio Controller.

Detection component includes a set of feature extraction algorithms that transform raw data into relevant walking information. Here, the internal sensors of the iPhone 4S (gyroscope, accelerometer, and GPS unit) are used to recognize events and states of the walker's activity process.

Audio controller is the component that generates sonic feedback. To generate and compose sound on the mobile device, the audio engine Pure Data[1] is used. The visual programming environment supports real-time audio synthesis and development - which is important to design and implement interactive sound in an exploratory manner. The Audio Controller provides functionalities to load sound files and play back sounds as they are needed (See Appendix D.1).

Database is a component providing data tables for storing predefined values and settings of the application. For instance, for each application a specific table needs to be defined that contains the names of the audio files.

In the next chapters this technical framework is used to develop a prototype for each design case. With the implementation of the prototypes, the components described here are further developed and extended by necessary functionalities in order to implement the *GangKlang* concept.

[1] Since the first release of the libpd library in 2010, incorporating pure data patches (programs) in iPhone and android applications is possible.

4 | Modeling the Walking Process

> *"But no activity is any sort of pure, undiluted problem-solving. Even the most articulately abstract problem-solving is made out of individual episodes that are themselves matters of routine."*
>
> —Agre, 1988, p.265

I started my exploration by laying out the numerous interplaying factors that can influence the walker's experience and related challenges for the design of interactive sound (Chapter 2). In the previous chapter, I argued that current walking applications base their selection of conditional factors and accordingly their process model for walking on a specific setting. These prescriptive approaches focus on setting-specific aspects of the walking activity (locative engagement, navigation and body movement). This chapter explores an alternative approach to modeling the walker's experience process. It takes an activity-centered perspective and abstains from a predefined setting. This approach focuses only on the walker's activity itself to understand and access the walker's unfolding context. Towards this result, I first use the concept of activity to describe the walking process in a general scheme and organize the inner workings of the analytically separated dimensions: walking movements, changing environmental conditions and the walker's cognitive engagement. Then secondly, I study empirically how the walker's movements unfold in changing conditions and how they can provide insight into contextual aspects. Thirdly, I operationalize the study findings in a walking model, named *Walking Phrases*, and discuss the possibilities it offers to consider the walker's context in design of interactive sound.

4.1 Walking in the Concept of Activity

As discussed in Section 2.4, the activity approach uses a hierarchical structure to organize the relation between body movement, changing conditions and mental processes. Organizing a person's activity in this three-folded structure of activity, actions and operations, the aim is to approach, 'unlock', the unfolding subjective experiences. In this section, I use this scheme to describe the walker's process and the interplay of walking movements, changing conditions and cognitive engagement in a general form.

As we have seen from the examples in the last chapter, walking can be motivated by very different needs: to move from one place to another, to experience art or to maintain physical health. This driving motive describes the top layer of the walking activity. The middle layer describes a series of goal-directed actions that a person consciously plans and undertakes to fulfill the higher-level need. As an example, turning into a particular street may be a partial step, one of many actions to fulfill our need to move to a specific place (for instance to see a friend). On the lowest layer, operations describe how the walker carries out conscious actions through a series of automatized movements. Operations are "transformed actions, which were consciously conducted in the beginning" (S. Bødker, 1995, p. 148), they have been performed over and over again and "become routinized and unconscious with practice." (Nardi, 1995a, p.37). Applied to walking, the rhythmic movement of shifting weight from one foot to the other (gait cycle) can be understood as the basic operational unit.

The transition between action and operation layer allows to describe the dynamic change of a movement from being more or less automatized and a person being more or less cognitively involved in it. For instance, a person walking to a friend's place for the first time, will consciously look for specific corners that he needs to turn off into. The more often the person keeps walking this route the more automatized the turning into corners will become and the less the person will be aware of it.

Operations (routines) are tightly intertwined with particular conditions. "Each operation corresponds to the concrete material (physical or social) conditions for conduction of the actions, and it is triggered when met by the specific, concrete, material conditions. Operations are sensorimotor units that a human being performs in a specific situation, without consciously thinking of them, to perform the actions that he or she is consciously aware of." (S. Bødker, 1989, p.177). A walking person constantly modifies the walking rhythm with regard to given conditions. For instance, a person may walk more slowly as the street gets busy, accelerate the walking speed to cross a side street or attune to the walking pace of a companion. What is worth noticing is that stable conditions favor automatized movements, which in turn, free up resources "to engage in other simultaneous activities." (Kaptelinin and Nardi, 2012, p.27). Hence, depending on given conditions, movements can be performed more or less automatically, moving from operation level to action level or the other way around. To describe it differently, the less conditions change, the more automatized walking becomes and the less the walker is cognitively involved with the walking process itself.

Describing the walker's process with the three-folded structure of the activity framework we gain a conceptual model of the walking process. This model provides a structure to explain and relate conscious acts and daily routine movements. In particular, the description of the operational layer provides a theoretical basis for how changes in the walking manner are intertwined with changing conditions, and how they go along with allocation of cognitive resources. In a study on everyday movement, Seamon (1980) has devised a structure of daily routines that is close to the operational layer described above. The author takes a phenomenological approach to study people's movement experiences in daily life. Seamon gives a rich description of routine movement experiences and his first-person based perspective provides a valuable complement to the abstract and structural description of the activity framework. Thus, I examine Seamon's findings briefly.

4.2 A Phenomenological Account on Walking

Seamon reports on three main characteristics of everyday movement: "(1) the habitual nature of everyday movement; (2) the importance of the body; (3) body and place 'choreographies.'" (Seamon, 1980, p.152). The first characteristic accounts for the reported experience that everyday movements are performed in an automatic manner and the absence of conscious awareness. These daily movements through which we put conscious goals into practice unfold without conscious direction and monitoring: "many movements are conducted by some preconscious process which guides behaviors without the person's need to be consciously aware of their happening." (ibid., p.153). Seamon illustrates this automatic process with a walking example: "She has no recollection of the great number of footsteps, turns, stops, and starts that in sum compose the walks from home to school. She finds herself at her destination without having paid the least bit of attention to the movement as it happened at the time." (ibid., p.153)

The second characteristic highlights the role of the intentional body that makes it possible for a person to perform routine movements while simultaneously engaging in other activities. To explain this phenomena, Seamon introduces the term body-subject:

> *"Without the structure of body-subject, people would be constantly required to plan out every movement anew - to pay continuous attention to each gesture of the hand, each step of the foot, each start [...] In this way, they rise above such mundane events as getting places, finding things, performing basic gestures, and direct their creative attention to wider, more significant life-dimensions." ibid., p.156-157*

With the third characteristic, Seamon accounts for the spatio-temporal dimension of daily movements. Here, the author differentiates between body-routines and time-space routines. Body-routines refer to a series of integrated movements through which a person sustains a task such as sewing. Body routines happen on a small scale. Time-space routines comprise a geographic scope and refer to "a set of habitual bodily behaviors which extends through a considerable portion of time." (ibid., p.159) The series of bodily behaviors in a time-space routine are body-routines in themselves and interwoven with and through space. For instance, a time-space routine may be the daily morning walk to the bus stop that is interrupted with a little visit at the favorite bakery. These bodily behaviors unfold in a particular spatio-temporal and social context. Once again, the author points out the dependence of routines and cognitive resources: "In managing the routine, repetitive aspects of daily living, time-space routines free people's cognitive attention for more significant events and needs." Building on these structures of routine movements and their spatial extent, Seamon argues for a routine-constituted concept of place. According to this understanding, a place emerges where the routines of different people meet: "an interaction of individual bodily routines rooted in a particular environment" (Seamon, 2013, p.151).

The philosophical-rooted phenomenology and the psychologically rooted activity framework are very different in terms of their approach to unlock daily experiences. However both refer to similar mechanics underlying the process of routine activities. Both explanations, the activity and phenomenological account, adopt an overarching need as the driving origin of a subject's activity in the world: "Movement, explored phenomenologically, indicates that the body is intelligently active and through this activity efficiently transforms a person's needs into behaviors." (Seamon, 1980, p.156). Both accounts agree that everyday activities are inextricably embedded in spatial and social conditions. In particular, Seamon's notion of time-space routines concurs with the operational layer of the activity in its description of body movement processes and their unfolding within environmental conditions. Moreover, Seamon provides a congruent explanation for the inner workings of routines and cognitive involvement. Both explanations concur that when movements have been rehearsed for a long time, they can be performed automatically and thereby free up resources to "engage in other simultaneous activities" (Kaptelinin and Nardi, 2012, p.27).

Thus, walking as an everyday routine movement is an embodied expression of both: the overarching and motivating need and the concrete conditions of the current situation. In the next section, I use these considerations as a foundation for an empirical investigation to understand the unfolding of walking movement and the structures described above in the concrete.

4.3 Studying Walking Movements in Context

The following study (Study A) was conducted as part of the Flow-Machines project and its third strand which explored enhancing the walker's experience through interactive sounds. Taking the main role in this strand of the project, I designed, conducted, and analyzed the study presented in the following. Two mobile applications were developed to carry out the study. The first application facilitates a location-based game and the second collects gait data. I implemented the game application together with my colleague Simon Bogutzky. The application for gait data collection was implemented by my colleague only. The study and its finding have been published as a conference paper (Hajinejad, Licinio Roque, and Grüter, 2017).

On an abstract level, the process of walking can be described by the gait cycle. However, that description of walking does not inform on changing conditions along the process. For the purpose of design, we are interested in what we refer to as semantic walking sequences. Semantic walking sequences describe the walking process with regard to contextual change and thereby provide access to understand experiential aspects of the walker's activity process.

To identify semantic walking sequences, we conducted a study on changes within walker's movement manner and how they are related to moment-by-moment interaction with changing conditions along the process. In doing so, we do not take a behavioristic understanding and analyze the changes in the walker's movement as a mechanical reaction to environmental conditions. Rather, we seek to understand the walker's movement and how it evolves along contextual changes as an individual embodied expression of the walker's encounter with the situation. *To what extent does the walker's movements provide access to contextual information?*

4.3.1 Study design

To map a vocabulary of semantic walking sequences we conducted a case study using the process-oriented method. The goal of the process-oriented method (Grüter, Oks, and Lochwitz, 2010) is to study change in the process, within which it happens. Here, we focused on changes within the player's walking manner and how these were related to the player's moment-by-moment interaction with the game and changing social and environmental conditions. I adapted the method to fit our particular study context and the analysis of the walker's movements. My procedure included the following steps:

- Designing a location-based game to create a roughly structured setting for walking.
- Playtesting the game and collecting process-data on player's walking activity including walking movement and game play data.
- Preparing the process-data for analysis by synchronizing data streams.
- Visual inspection and analysis of the process-data.

4.3.2 Game and playtest

We designed a location- based mobile game that encourages players to walk through a dynamically generated soundscape. We use the game as a reference framework for the player's walking activity. This way, we create a coarse structure for the player's walking process. In the study five girls (aged 9 to 14) played the

Figure 4.1: Picture of participant using the mobile App and playing the game in Study A.

game during a course on healthy lifestyle. Parents were informed about the study goals and gave consent to observations and data collection (See Appendix A.2). We used two mobile applications. The first application realizes the game and collects game play data (game app). The second one collects biomechanical motion data about the player's walking movements (gait data app).

The players individually explored the playground, a one- hectare park, divided into four game sections. To play the game each player was equipped with a smartphone and headphones. The players were given the task of exploring the park by listening carefully to the soundscape and to identify the location of their personal *sweet spot* a particular location of five square meters. By putting on the headphones the players could experience an augmented version of the park. While walking within the park, the player heard a dynamic soundscape composition of three sound layers. The first layer is a soundcarpet reflecting the atmosphere of the predefined park section the participant is currently traversing. The second layer interactively resonated with the steps of the player, in the form of percussive sounds [1]. Entering the personal sweet spot triggers the third sound layer, a striking sound motif[2]. The sweet spot was generated dynamically

[1] http://gangklang.gangs-of-bremen.de/wp-content/uploads/2020/01/gait_diako_hs1.wav
[2] http://gangklang.gangs-of-bremen.de/wp-content/uploads/2020/01/specialSound.wav

and individually for each player around the GPS position where the player stayed for several seconds after some minutes of walking. The players did not know the conditions that generated a sweet spot. They had the task to find the sweet spot by means of the special sound motive and to mark it by pushing a button in the mobile app.

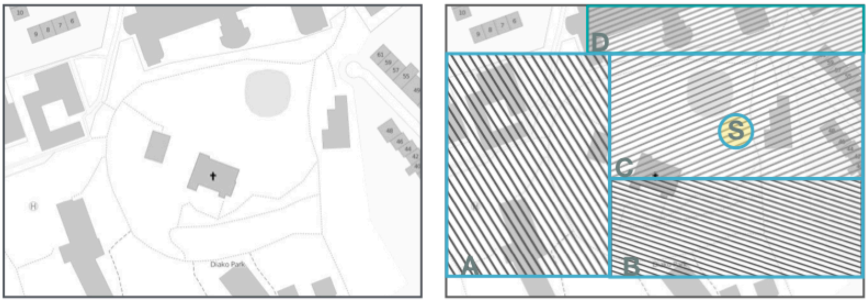


Figure 4.2: Play area and game sections in Study A.

4.3.3 Data collection and preparation

For each player, we collected gait, location and game play data streams to reconstruct their individual walking process. We collected this data by means of two applications (game and gait data collector) implemented on the iPhone 4S, using its internal gyroscope, accelerometer, and GPS unit. Each player was equipped with two iPhones, one to play the game and another on in the trouser pocket for the purpose of gait data collection. After the game play we conducted a semi-structured interview with each player.

Gait data

Walking is a cyclic movement which results in an oscillating movement in the various accelerometer and gyroscope data streams. For instance, visualizing the time- series data 'AttitudeRoll' of the iPhone, we can see a player's hip rotation while walking. From the moment when the player takes up the foot from the ground to make a step (with the leg to which the iPhone is linked) to the next moment when the same foot takes up from the ground an oscillating movement is created (Nowlan, 2009). One period length of this movement (oscillation cycle) corresponds with one gait cycle (two steps). The amplitude of one oscillation corresponds with a step length.

Location data

Visualizing the positioning data stream (GPS) of all the players on a map, we are able to reconstruct each player's walking route in the park and their movement from one game zone to another. Moreover, we can reconstruct when a player encounters other players and differentiate between phases when a player walks alone or together with others.

Game data

Logging data was collected by the game application informing on events such as when and where a player's sweet spot was generated and when a player marked a sweet spot.

Synchronizing data streams

An essential step in the process-analysis is to relate the data streams that have been collected. All data streams (gait, location, game data) were time coded. We used the softwares ChronoViz[3] and TrackLab[4] to link the visualization of the player's gait data with their location track on a map. Further, we marked the locations of generated sweet spots and the game sections on the map. In the course of the analysis process, we added further annotations to the time

[3] (Fouse et al., 2011)
[4] (*Tracklab - Human* 2019)

stream to mark specific events such as when a player enters a new game section, and joins or leaves other players.

Data analysis

According to the structure of activity, small-scale units in the process and individual changes can only be understood in the context of the overarching activity and its motivation: "The actions cannot be understood, however, without a frame of reference created by the corresponding activity" (Kuutti, 1995, p.15). Following this idea, the analysis starts with a description of the overall play process. This stage is followed by a more fine-grained analysis of shorter walking sequences. In the fine grained analysis, I used the steps as described by Grüter, Oks, and Lochwitz (2010), howevere I added a sixth step.

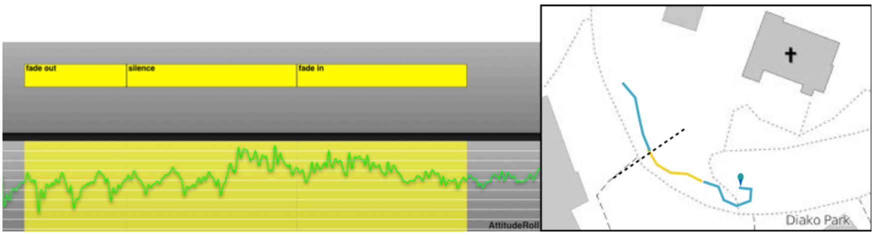


Figure 4.3: Visualization of a walking sequence by means of motion and location data streams.

I repeatedly walked through the synchronized data streams (gait, location, game data) of each individual player with the purpose to:

- Capture the meaning of the whole process: understanding the walking overall activity as it takes place within the gameplay;
- Identify events that change the course of the individual activity process or irritate the researcher;
- Identify the state before the event and the state afterwards;

- Analyze both dimensions, the processing system and the changing context: with regard to the walking activity, we consider the gait cycle, the core mechanics of walking as the processing system and everything surrounding the gait cycle as context;
- Attempt to explain the change in the process by means of the results gained in steps 3 and 4.
- Explore to what extent the walker's movement embodies contextual encounter.

In the following, I will elaborate on these analysis steps and their results with a single case of a female player Lara.

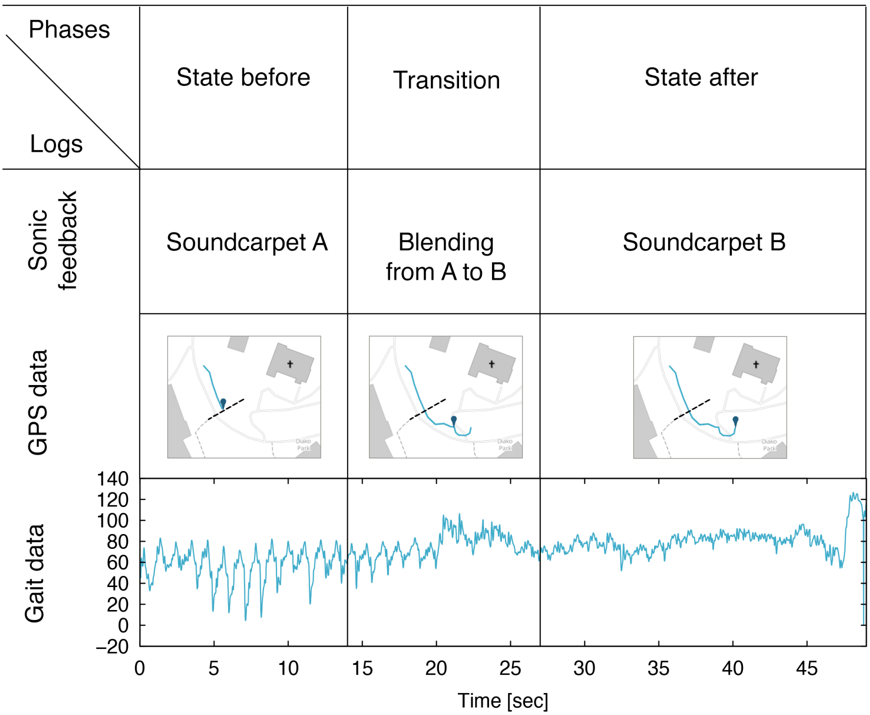


Figure 4.4: Organization of multimodal data on a walking sequence of player Lara.

4.4 Results

Step 1: Female player Lara walked for about 20 minutes in the park, playing the sonic discovery game. Her walking process can be divided into three episodes marked by walking alone (6 min) and hearing the sweet spot's sound motive, joining a group of other players and discovering the park together with them (11 min) and parting from the group, walking alone again (3 min) and marking the sweet spot.

Step 2: I now elaborate on one example of change within Lara's walking movement that happens in the first episode of her walk. After 20 seconds of walking, Lara reduces her step length abruptly (see Figure 4.4).

Step 3: Lara's walking movement within the first 45 seconds can be divided into three phases. The first phase (state before) describes the time period while she is walking with a consistent step length. The second phase (transition) is initiated by an abrupt reduction of the stride length. The third phase begins as Lara keeps on walking in a consistent step length (however with small steps) again.

Step 4: I reconstruct the time period of 45 seconds within which this change evolves by interrelating three data streams: sonic feedback (log files), spatial movement (GPS data) and walking movement (see Figure 4.4).

> Game conditions: From putting the headphones on and starting playing until second 15 Lara is walking within game section A and hearing soundcarpet A. As she passes the augmented border and steps from game section A into section B, the soundcarpet changes accordingly: soundcarpet A is blended out and after 5 seconds of silence soundcarpet B is blended in.
>
> Spatial and Social conditions: The visualization of the GPS data on a map shows that Lara is walking alone and stepping from one

game section into another.

Walking movement: From the visualization of gait data (hip rotation time-series) we can see that Lara's steps have a relatively consistent big length for about 20 sec. Then an abrupt reduction of the stride length is indicated in the visualization of the hip rotation time-series data that shows a reduction of variation. Afterwards, her steps remain small for a while.

Step 5: I interpret the sudden change in Lara's walking movement (from big steps to small ones) as an embodied expression of her experience of consistency and change in the soundscape. This experience includes Lara's increased attention and uncertainty as the change in the soundcarpet happens unexpectedly for her (she encounters the change in the soundcarpet for the first time). The experience of this change in the soundcarpert is highlighted by the fact that Lara is walking alone and not distracted by other players. After the change, she continues walking in an attentive manner with small steps for a short while.

Step 6: Taking a closer look at Lara's walking movement and how it evolves in this period of time, I distinguish two dynamics. Lara's walking manner in phase one (while she is walking in game section A) and three (while she is walking in game section B) are clearly different with respect to the stride length, however these phases are similar in terms of walking dynamics as both phases are characterized by a stable stride length. I describe this walking dynamic with the term 'walk-along'. The second walking dynamic refers to the transition phase that is characterized by an abrupt reduction of the step length; I refer to this second movement dynamic as *approaching*. The variability of Lara's stride length indicated her experience of contextual consistency and change.

In the following, I summarize the above-demonstrated observations. Combining the results on the individual player's walking process, I found three types of relations between the walker's movement manner and context: 1) Change relation; 2) Expressive dynamics and 3) Locative relation. I will elaborate on these using the example above.

4.4.1 Change relation

The results show that a player's walking process can be segmented into sequences with stable walking dynamics and phases with considerable change. For instance, the sequence in table 2 named walk-along is characterized by a steady step length. In contrast, the sequence named *approaching* is characterized by a sudden decrease in step length. These walking dynamics can be related to contextual stability and change as illustrated above.

4.4.2 Locative relation

The results indicate that the walker's movement manner can provide insight to location-related aspects. Following the course of Lara's play and how her walking movements evolved, I observed location related factors that initiated, sustained and ended Lara's walking manner. In the first episode, when Lara is walking alone and still getting familiar with the soundscape, it is the soundscape sections that structure her walking manner. Just as demonstrated in the time period above (Table 1), Lara continues walking in a sustained manner while walking in one soundscape section and changes her walking manner as she enters a new soundscape section. In the second episode, Lara's walking behavior is predominantly structured by places of the other players. For instance, she stops walking when she reaches the playground where other players have gathered. In another episode when she is walking in twos, she continues walking across different soundscape sections and stops at the sweet spot of the accompanying player. In the last episode Lara separates from the other players and heads towards the location of her sweet spot. In this episode, it is again the soundscape that structures her walking movement. As she comes closer to her sweet spot her walking manner changes to little steps and she walks in a circle. Leaving her sweet spot behind, Lara starts walking in a steady manner again. Thus, whether the player continues walking, changes his or her walking manner or stops is informative concerning the walker's relationship to a location.

4.4.3 Cognitive load

In this study, we did not collect data to access the walker's attention focus and cognitive load. However, relating the player's walking movement to game and social conditions allows us to differentiate between phases that are more or less critical as they require special attention. For instance, moments when the striking motif of the player's sweet spot is triggered. The results show that the player's regular walking movement is interrupted in critical play phases. Thus, the study results support the inner connection between routine movements and cognitive load as discussed in section XY).

Taken together, the results suggest that the walker's movement process can be segmented into sequences with semantic information. First, the walker's movement dynamics can provide access to stability and change of conditions that are meaningful to the walker. Second, these sequences can be used to infer on the relation between the walker and the location. Third, these sequences can be used to infer on required cognitive load.

I used the single observations for plausible generalizations on four semantic walking sequences, which are presented in the next section.

4.5 Findings

Relating a player's gait, location and game data provided me with a highly detailed account on each player's walking process and how it unfolds as situated movements within a specific spatio-temporal and social context. The question guiding the analysis was if and how the walker's movements can provide access to contextual information.

Based on the observations, I define a vocabulary of semantic walking sequences that I refer to as *Walking Phrases*. Using the vocabulary of *Walking Phrases*[5], allows us to segment the walking process into units with different contextual variability: units with a consistent context (named *walk-along*), three units where the context is shifting (named *turn*, *approaching* and *stopping*) and units where the context is highly variable (named *none*). For instance, all sequences where the walker keeps a regular stride length for more than four seconds are referred to as a *walk-along phrase*. Walking sequences within which the walker performs a *walk-along phrase* may differ from an objective perspective such as the route, time of day, social conditions and so on. However, what these walking sections have in common is that the walker experiences a contextual stability within which he or she can continue walking in a steady manner with a steady stride length. This experienced contextual stability enables the walker to perform the physical walking task in an automated manner while mentally engaging with other things. The three *walking phrases*, *turn*, *approaching* and *stopping*, refer to short walking sections where the walker experiences a change and a related attention allocation. All other sequences that do not meet these *walking phrases* are associated with a highly variable context and accordingly a high cognitive load. As mentioned before, it should be highlighted that walking phrases describe contextual stability, shift and instability from an individual perspective.

4.5.1 Walking Phrases

Walking Phrases are my approach to gain access to the walker's context in order to accommodate it in the design of interactive sound. *Walking phrases* can be detected as they unfold in the walking process, and provide insight into when walkers experience their contextual conditions as steady and undemanding, and when disruptions appear that involve them more strongly in their walking activity. In the following, I illustrate the implications of each *walking phrase*

[5] Each element in this vocabulary is referred to as a walking phrase

for design and how they can be used to inform the composition of interactive sound.

Walk-along phrase: These phrases indicate that the walker experiences a contextual stability, as only when experiencing stable conditions, the walker keeps walking in a steady manner with a regular step length. During these stable sequences, the walker can perform walking movements effortlessly and is thus more receptive to other things. It is here and now that a phase emerges, which can be used - for instance - to intensify the walker's relationship with interactive sound. A possible example would be to increase the complexity of interactive sounds by introducing new sound layers or striking up a melodic theme. Another way of intensifying the relationship would be to increase the granularity of interactivity and thereby involve the walker more strongly in the sonic interaction.

Turn phrase: The distinctive feature of the *turn phrase* is the concomitant new perspective. As the walker performs and feels the turning of her own body so does her perspective change. Thus, a *turn phrase* indicates at least a slight change of context, as the walker's visual perspective changes, new objects become visible and new action opportunities are presented. The *turn phrase* is like opening a door, metaphorically speaking, and the walker is prepared to encounter something new. The *turn phrase* implies that conditions are favorable to present to the walker new aspects and contents. This could be for instance the change of interactive sound into a different musical key.

Stopping phrase: When the walker stops walking, it is for a good reason: maybe the walker has reached a traffic light on a busy street, or maybe encountered someone familiar that he or she wants to talk to. It may even be because the walker suddenly has an important thought which demands his or her full attention. In any case, the *stopping phrase* indicates that something relevant to the walker has occurred, catching his or her attention. Thus, the *stopping phrase* is accompanied with an increasing cognitive load. Interactive sound could be adapted accordingly by turning down its volume or reducing its complexity. This gap provides an opportunity to highlight the real-world soundscape.

Approaching phrase: In an *approaching phrase* the walker slows down abruptly, indicating a sudden contextual change. Somehow the situation has become more demanding, for instance executing the walking movement became more difficult due to a busy street where the walker has to adjust his walking movements to other pedestrians or conditions of the place. The conditions are comparable with the ones of the *stopping phrase* but maybe not as demanding. The change might not be an obstacle, but it can be a new interest, maybe something else has caught the walker's attention. Although the circumstances allow the walker to continue walking he or she is facing an increased load and can no longer perform as before. As the walker is engaged otherwise it is reasonable to decrease the feedback intensity.

	Walk-along	Turn	Approaching	Stopping	None
Distinguishing feature	Steady Gait cycle duration	Direction change	Shortening Gait cycle duration	Ending Gait cycle	Variable Gait cycle duration
Framing conditions	Stable	Shifting			Unstable
Load implications	Low (wandering-mind)	Low-high increase	Medium increase	High increase	High

Figure 4.5: Walking phrases, their characteristics and implications.

4.5.2 Implications for interactive sound design

Walking phrases enable us to approach those conditions that are effective for the individual walker as they bring about changes within the walker's movements. The advantage of using *walking phrase* as an analysis unit, is that it allows us to simultaneously infer different dimensions of the walker's context. In the following, I reflect on the type of contextual information that can be inferred from *walking phrases* and how they can be used in design of interactive sound.

Temporal structure

The segmentation of the walker's activity into *walking phrases* allows a temporal structuring of the individual walking process. This structuring can be used to inform the conception of a dramaturgical guideline and selection and arrangement of sonic material. For instance, this temporal structure might be used to balance change between sonic feedback that induces tension and relaxation.

Translocational Design

Walking phrases also provide the opportunity for a spatial structuring. Each *walking phrases* allows inferring on how the individual walker perceives spatial conditions. *Walk- along phrases* indicate the experience of a coherent spatial section. In contrast, changing from one *walking phrases* to another can be interpreted as a marker of a new spatial section. Observing a walker repeating a certain *walking phrases* at a particular location, allows for identifying personal landmarks, that is places that are meaningful to the individual walker. These personal landmarks can be used for anchoring *Placed Sound*[6] and to implement translocational design. I find this possibility particularly promising for the design of mobile games or other location- based interactions.

[6] The category Placed Sounds was introduced (Behrendt, 2010) to refer to mobile sound art practices that locate sound to a particular physical location.

Attentional Balance

Walking phrases provide insight into when the walker experiences a prominent change of conditions and thereby enables to infer on the walker's attention resources. As outlined above, system behavior and feedback complexity can be balanced according to the walker's attention capabilities.

Affective Design

Various research findings support the correlation between dynamic characteristics of walking movement (acceleration, velocity) and affective qualities (Crane and M. Gross, 2007; Kang and M. M. Gross, 2016). In HCI several works have applied experiential qualities of movement as an input modality to design experience-oriented interactions (Alaoui et al., 2012; Bernhardt and Robinson, 2008; Fagerberg, Staahl, and Kristina Höök, 2003). The dynamics of a *walking phrases* can be used to infer on affective quality. Building on this, interactive sound can be adapted to illustrate and intensify (paraphrase) the walker's current movement quality or run directly in contrast to it.

4.6 Discussion

This chapter has set out the walker's activity process as a key to access the conditions within which the activity takes place, as an alternative to predefining a walking setting. Describing walking with the activity structure provided us with an understanding of routine movements that underlie the activity process. These movements can be understood as an embodied expression of the particular conditions they are embedded in and indicate varying cognitive demands. On the basis of this conceptual understanding of the walking process, a study has been conducted with the focus on identifying semantic walking movements that provide access to the walker's context. The outcome of this chapter is

Walking Phrases: a vocabulary for modeling the unfolding walking process. With *Walking Phrases* the course of walking in everyday life is segmented into a series of units, each framing a meaningful experiential building block of ordinary walking. Changing from one *walking phrases* to another, the walker corporally encounters changing conditions, while attaining the goal of reaching the target destination.

There are limitations to our process-oriented case study and the resulting model. First, it is an in-depth look that explores how the walker's movements are related to the changing context. The contribution lies in demonstrating possibilities for using the walker's movements to gain insight into context beyond explicit statements, and combination and interpretation of numerous environmental data streams. Moreover, the theoretical concepts outlined above are substantiated with micro level data. Second, the informative power of *Walking Phrases* is limited to basic structures of context only. Needless to say, that context as it unfolds in the activity process cannot be fully represented for reasons of complexity. Rather than describing specific qualities of walking moments, the model directs attention to process change and the attentional and environmental conditions associated therewith. I discussed the possibilities that *Walking Phrases* provide for a (dramaturgical) design that builds on the walker's individual movement and is anchored within the walker's spatiotemporal and social context, as an alternative to a predefined setting.

The use of *Walking Phrases* in design of interactive sound will be explored in the next chapter.

5 | Translating into a Sonic Expression

> *"This measured motion can be easily joined to a series of musical sounds, since musical sounds themselves always imply an idea of movement. Such is the origin of rhythmical songs and the dance."*
>
> — Sulzer, 1996, p.82

In Chapter 3, I have illustrated the possibility to foreground various aspects of the walker's activity and identified two experience-directing pillars in design of interactive sound: a) the translation of walking activity into a process model and b) the translation of the process model into a sonic expression. Following this logic, I have developed a vocabulary for modeling the successively unfolding walking process in the previous chapter. This chapter's focus is on the second task: translating the walking model into a sonic expression. *How can we translate the walker's data into a sonic expression with the purpose to foreground the experience of the unfolding walking process?* This chapter answers this question by developing a framework for guiding the translation process. The development of the framework is presented in three steps.

First, the chapter starts with a closer look at the intended outcome of the translation process. A sonic expression that is effective for walking in the mobile everyday life context, must be designed to comply with the walker's everyday listening mode. What are the structures that organize how we experience the multitude of sounds in daily life? Here, I draw on the concept of acoustic communication and the notion of soundscapes to derive principles for organizing the individual sounds generated by the interactive system.

Second, I use these organizing principles to draft a basic schema for translation. I substantiate the translation schema by implementing instances for different walking settings. The chapter continues with an overview on three design cases, their particular requirements for sonic expression and how they helped to concretize the translation schema.

Finally, commonalities of all instances are described, including typical phases of the translation process and concerns to be taken into account. As a result, *GangKlang-Translations* is presented, a framework for designing dynamic sonic expressions that facilitate the experience of the unfolding walking process. The framework supports the design with three elements: a) a schema to organize interactive sounds and a strategy to draw the walker's experience towards the walking process, b) translations objects for implementing interactive sound and c) a prototyping system to support a first-person perspective in the design process.

5.1 Experience of Sound

An interactive system that translates the walker's movements into sound will elicit an array of sounds along the walking process. This way a sonic environment emerges while using the system. In order for the sonic environment to function as a sonic expression of one's own walking activity, they must be organized in an experience-oriented manner. In this section, I provide a perspective on the experience of sound in everyday life. For presenting this perspective, I draw on Barry Truax and his communicational approach to acoustics (Truax, 1984) and on the notion of soundscape as introduced by Murray Schafer (Schafer, 1994). Both of these notions frame sound from the perspective of the experiencing subject in everyday life, and offer important considerations for designing interactive sonic gestalt. Both of these interrelated concepts focus on environmental sounds and on sound as a mediator between the environment and the listener. They are specifically concerned with promoting awareness for how the sounds of a particular environment contribute to peoples' experiences of this environment "Acoustic experience creates, influences and shapes the habitual relationships we have to any environment." (Truax, 1984, p.11). Truax develops with acoustic communication a general framework for "understanding the intricate system of meanings and relationships that sound creates in environmental contexts." (Truax 1996, p. 58). The term soundscape refers to any particular acoustic environment that is studied and provides an understanding for how people experience sounds in an organized manner.

I particularly discuss three related aspects of everyday listening: a) experience of sound sources, b) the listener's context specific attentiveness to sounds and c) the organization of sounds in the listener's experience according to their effectiveness.

5.1.1 Sound sources and streams

In his communicational approach, Truax complements the objective physical understanding of sound as energy with the subjective perspective of the sound experiencing listener. The general idea of acoustic communication is that sound is a means for humans to understand and make sense of the environment. In this understanding, sound is a medium between humans and their environment, a medium through which the listening person experiences and interacts with environment. A key issue in this perspective is to distinguish between hearing and listening. While hearing addresses the general physiology of a human and the passive process of auditory stimuli, listening refers to the process of a subject making actively use of of acoustic information "ability to interpret information about the environment and one's interaction with it" (Truax, 1984, p.16).

In the domain of sound design, one way to characterize the listener's way of experiencing sound is to distinguish between different modes of listening. A very rough division has been made contrasting everyday listening (casual) to musical (reduced) listening (Tuuri and Eerola, 2012).

Reduced listening attends to a mode where a subject is focusing on the qualities of sound itself. In particular when we listen to music we are usually paying attention to the characteristics of the sound and how they evolve and progress.

Casual listening refers to a mode where a person experiences sound as a reference to an event or a process. In daily life, rather than listening to isolated attributes of sound, we experience what Moore names "discrete sound sources or auditory objects" (Moore, 2012). The source-identifying functionality of listening is particularly highlighted by Gaver's definition of the term *everyday listening*: "the act of gaining information about events in the world by listening to the sounds they make." (Gaver, 1988). Considering the informative character of sound in daily life context, Gaver suggests the notion of sound as "audible source attributes" (Gaver, 1993) and differentiates between everyday and musical listening "Everyday listening is the experience of hearing events in the world rather than sounds per se." (p.1). This perspective concentrates on the indexical role of sound and investigates the influence of sound on the listener's experience focusing on the "events that we actually obtain through listening" (ibid., p.3). The experience of sound is not determined by the properties of sound but by the event that the listener attributes to. Thus, the object of study is the relation between the sound-producing event, the sonic properties and the information that the listener derived therefrom.

At this point it is important to consider the distinction between sound source and sound stream. Moore describes the difference between sound and source as follows: "A source is some physical entity that gives rise to acoustic pressure waves, for example, a violin being played. A stream, on the other hand, is the percept of a group of successive and/or simultaneous sound elements as a coherent whole, appearing to emanate from a single source. For example, it is the percept of hearing a violin being played." (Moore, 2012, p.285). That is, in our everyday listening we do not experience sounds isolated but as part of a sound stream that makes a process audible.

5.1.2 Context-specific attentiveness to sounds

> *"In a communicational approach, context is essential for understanding the meaning of any message, including sound." (Truax, 1984, p.10)*

A further aspect of experiencing sounds in daily life concerns the listener's attention. How do we select sound sources? In his communicational approach, Truax points out that humans have different modes of attending to the sounds in their environment. He distinguishes between different degrees of attentiveness and the capability to focus on certain sounds within the sound space: "The level of attention may be casual and distracted, or in a state of readiness, and its scope may be global (a general "scan" of the entire environment) or focused on a particular source to the exclusion of other sounds." (ibid., p.16). Here, Truax puts an emphasis on the context within which sounds are perceived: "The way in which a sound functions for the listener depends on its social and environmental context."(Truax, 1984, p.24). In their revised taxonomy of listening, Tuuri and Eerola distinguish between three dimensions of listening. Here, the degree of attentiveness and the functional processing of sounds each represent one dimension of listening.

5.1.3 The organization of sounds

The term soundscape was coined by R. Murray Schafer [cf. 33, 40] and refers to "any acoustic field of study" (Schafer, 1994, p.7). A more detailed account of the term is provided by Truax: "An environment of SOUND (or sonic environment) with emphasis on the way it is perceived and understood by the individual, or by a society. It thus depends on the relationship between the individual and any such environment. The term may refer to actual environments, or to abstract constructions such as musical compositions and tape montages, particularly when considered as an artificial environment." (Truax, 1984). Schafer uses the term sound event to refer to individual sounds within a soundscape "the smallest self-contained particle of a soundscape" (Schafer, 1994, p.274). Using the term *event*, he particularly highlights the contextual embeddedness of a sound, or as he calls it: "the referential aspects of sound". (ibid., p.131).

An essential criterion in studying a soundscape (soundscape studies) is about the interplay of the various sounds that are emitted and their balance. The soundscape of an environment can support or make it more difficult for the listener to perceive and interpret sounds and thus have an impact on the effectiveness of sound. The sounds emitted by an environment may be overcrowded, masking each other and making it difficult for the listener to perceive and interpret them. The soundscape of such an environment is characterized as low fidelity (lo-fi) in the soundscape terminology and is often found in large cities. "Today the world suffers from an overpopulation of sounds; there is so much acoustic information that little of it can emerge with clarity. In the ultimate lo-fi soundscape the signal-to-noise ratio is one-to-one and it is no longer possible to know what, if anything, is to be listened to." (ibid., p.71) By contrast, the sounds of a high fidelity (hi-fi) soundscape are clearly discernible and well balanced. Accordingly, a soundscape can be more or less meaningful to a particular listener and contribute more or less to the listener's wellbeing.

In order to characterize the impact of sounds in a soundscape, the soundscape terminology distinguishes three themes of sounds: keynote, sound signal and soundmark. In accordance with the conceptual emphasis on the subjective experience of sound, the criterion for classifying a sound into one of the three themes, is the role of the sound in the listener's perception and not the physical parameters of the sound. What matters is the organization of the sound within the listener's perception, whether the listener perceives a sound as part of the 'ground' or 'figure' in the acoustic environment. This organization is dependent on the listener's intention and attention focus as well as on the prevalence of the sounds "their individuality, their numerousness or their domination" (ibid., p.9). However, the acoustic parameters of a sound can contribute to the way it is perceived. The specific features of acoustic warning sounds (high frequency), for instance, support them in being pushed into the perceptual foreground.

Keynote sounds of a soundscape are those, which the listener usually does not listen to consciously. As an example, keynote sounds of a busty urban environment might be traffic sounds, footstep sounds of pedestrians and music from cafés. Although keynote sounds are not in the focus of the listener's attention, they are decisive for how other foreground sounds are interpreted. A listener will interpret the ringing of a cellphone quite differently, depending on whether the keynote situates the listener in a library or a supermarket. The keynote of a soundscape can be understood as an interpretation frame through which listeners situate themselves "it is in reference to this point that everything else takes on its special meaning." (ibid., p.9)

Sound Signal are those sounds towards which the listener directs attention to.

In a busy street this might be the voice of the partner or the cell phone ringing.

Soundmark is used as an aural pendent to the term landmark. It refers to sounds that distinguish a location with a specific quality for a particular group of people and thus contribute to the identity of a specific place.

5.2 Considerations for GangKlang

What indications do the perspectives of acoustic communication and soundscape give us on how to organize interactive sounds in a sonic expression?

The communicational approach puts a person's interaction with the environment in the center. Nevertheless, it offers an important basis for which factors have to be considered in order to understand the experience of sounds in daily life. Truax sets out the form-giving power of sound. That is, to pay attention to the fact that transformation into sound is inevitably linked to a particular characterization of the starting material (in our case the walking activity). As we have seen in the examples presented in Chapter 3, interactive sounds are used to foreground different aspects in the walker's experience. Depending on what the designer chooses for translation (the event that is made audible) and the sonic attributes (envelope, timbre) that are used to render the event (the source) a specific identity is attributed to it. By representing a walking moment or process change through a sound with specific characteristics, the designer can induce a certain perception of this source. In other words, the designer attributes certain characteristics to the source by sonifying it.

Moreover, acoustic communication elaborates an understanding of sound that emphasizes its context-dependent impact. According to this understanding, sounds are not objectively isolated units in themselves but their meaning can only be understood with reference to the walker's context. "A sound means something partly because of what produces it, but mainly because of the circumstances under which it is heard." (Truax, 1984, p.xii). Truax refers to context as environmental and social conditions. In contrast to this, this thesis takes an activity-centered perspective and takes the walker's activity for defining context. As a principle for translation, the designer has to be aware that the user will hear and experience the sounds in relation to the walking activity. It is not only the sound characteristics that affect the walker's experience, but the overall composition, the unity of movement and sound that has an influence on how we experience walking and the meanings we attribute to sounds.

The soundscape perspective considers the overall composition of the various sounds in an acoustic environment and provides a terminology to organize them. Thus, the soundscape perspective is informative for structuring interactive sounds in a sonic expression. An interactive system that translates the walker's movements into sound will elicit an array of sounds with each use. The sonic environment that emerges while using the system can be understood as a soundscape. Following this line of thought, the soundscape themes (keysound, sound signal and soundmark) can be used as a schema for the translation of the walker's activity into a sonic expression. This tripartite soundscape structure shows a way for how different processes can be made audible in one sonic expression while preserving their distinguishability. Making use of different sound streams, different dimensions of the walker's process (such as the physical movement and location change) can be rendered in a sonic expression. Moreover, through increased change, individual streams can step into the foreground of attention and thus emphasize an aspect of the walker's activity. These considerations were used to inform the translation schema for *GangKlang*.

5.3 Developing a Translation Schema

> *"The general perspective and the specific instantiations are mutually elaborative - the general perspective is what ties the specific examples*

together, and what makes each of them important, and yet it is only through the examples that it is possible to understand the general perspective that is being advanced." *Wensveen and Matthews, 2014, p.1*

The translation schema to be designed provides a structure for the sonic expression. The main goal was to design a sonic expression that is made up from interactive sounds which evolve along the individual walking process and are organized in a gestalt (overall form). This way, the user shall experience a dynamic sonic expression as a dimension of the own activity. Through the sonic expression walking events, processes and qualities shall become audible. Towards this goal, the sonic expression has to start, evolve and end with users' walking process and its characteristics need to correspond with peculiarities of the user's activity. The dynamics of the sonic expression need to correspond to the user's walking process and rhythm. Significant changes of the sonic expression need to correspond to changes in the user's walking manner.

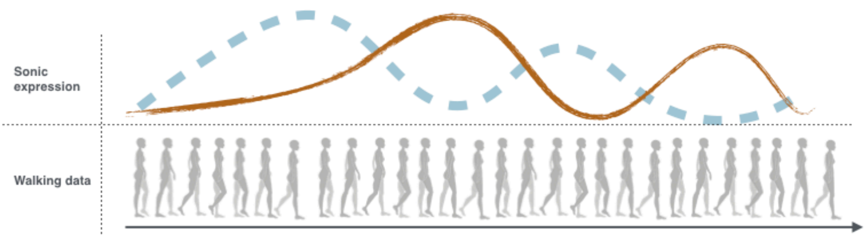


Figure 5.1: Schematic illustration of the ideated sonic expression and its composition from different sound streams that evolve along the walking process and are dynamically accentuated.

Drafting a schema

The schema incorporates the principles of sounds organizing in streams and sound themes. The schema includes constructs that use walking data to trigger and organize sounds in a number of sound streams. Each stream reflects one aspect of the walker's activity process. The sound streams have to evolve in a distinguishable and balanced way. The streams present in the sonic expression are more or less accentuated. The idea here is to use the dynamic accentuation of sound streams as a means to direct the walker's attention to the respective walking aspect and to strengthen the walker's experience of this aspect.

In order to channel walking data into different sound streams, corresponding constructs are needed. Each construct has to create sounds with characteristics according to its assigned sound stream in real time. Further, it needs to take the particular type of walking information that it reflects as input. However, as highlighted by Truax, the experience of sounds is context-specific. Accordingly, the translation schema can only be formulated in a very general manner and needs to be specified in context of the concrete walking activity and data.

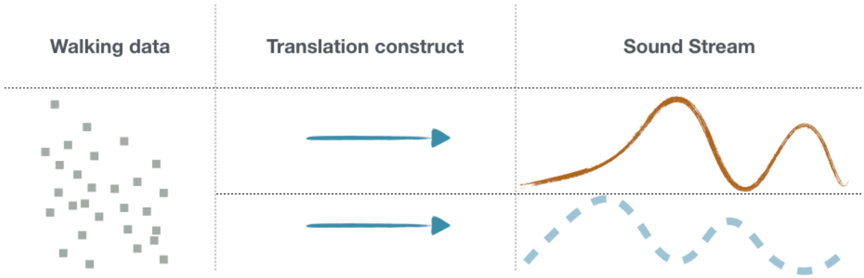


Figure 5.2: The basic structure of the translation to be designed and implemented.

Substantiating the translation schema

The initial translation schema was used to guide the design of interactive sound in three design cases and vice versa, the prototypes were used to substantiate the abstract translation schema with concrete formulation and implementation (Figure 5.3). The use of the schema was intended to deepen the understanding on how the relation between walking process and sound streams can be designed and result in formulating the translation constructs more precisely.

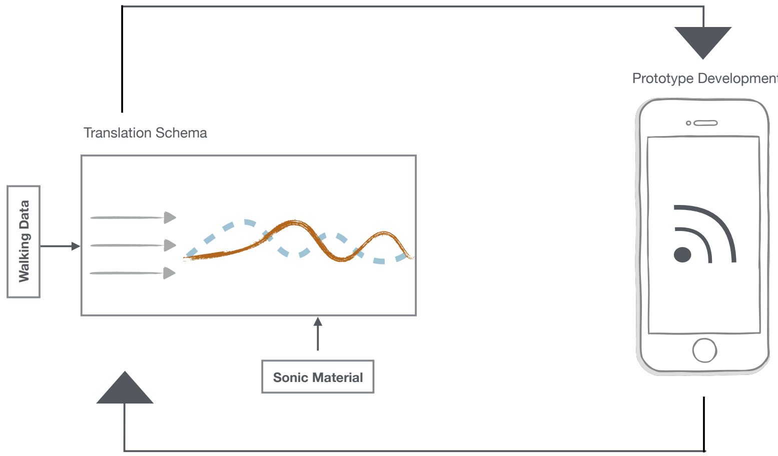


Figure 5.3: The mutual influence of the translation schema and the prototypes.

In each design case, a smartphone application was designed and developed that incorporates the user's walking data as user input to trigger and modify sonic output. In each design case, the application addresses a specific walking setting (different with regard to use case and target group). What they hold in common is that each application translates the user's walking activity into a sonic expression in real time for the purpose of facilitating the walker's experience of the walking process itself. More specifically, the objective of all translations is to spur a more intense engagement with the walking process itself. In the first two prototypes, the walker's activity is limited to predefined areas. In the first case the walking area is restricted to the park. In the second case, the walking area is loosely defined by game locations. In the third case, the walking is area is not restricted at all. The prototypes have been developed one after the other and each prototype builds on the findings of the foregoing. Thus the prototypes can be regarded as a further development of the same concept.

In what follows, the three cases will be presented. In accordance with this chapter's focus on the translation process, the descriptions are limited to the particular walking context and the purpose of sonic expression. The aim is to provide a basis for discussing principles and constructs of the translation concept that can be abstracted from the concrete walking setting.

	Audio Game	**INSP Tripton**	**Flow-Maschine**
Walking setting	Exploring a Park	Playing a Mobile Game	In Everyday life
Spatial limitation	Park area	Game locations	Unlimited

Table 5.1: Overview on the walking activity in the three design cases.

5.4 Design Case: Audio Game

In this design case, the translation schema was used to create a location-based audio game. The game was developed to be played by girls (aged 9 to 14) during their healthy lifestyle course. The girls visited this course for about a year due to overweight problems. The aim of this course is to introduce kids to a healthy diet and to motivate and encourage movement activities. The game was used in a study to encourage and to frame the participants walking behavior. Thus, this specific prototype was used as a means of inquiry. The purpose of the exploratory study was to investigate ordinary walking behavior in order to gain a better understanding of the structure underlying the walking activity. The study and its findings have been discussed in Chapter 4. This section's focus is on how interactive sound was designed and used in the game to encourage exploration of the park.

Walking setting

The walking area was a park of about one hectare in size. The park is structured by a main path and some landmarks: a pond, a playground, a small church and a small building where the healthy course takes place.

Design Intention

The main intention for creating the game was to provide the players with a motivation for walking in the park, without, however, intruding overly into the walking activity and how it was carried out. The girls knew the park from their weekly visits to the course and from other location-based games. The challenge was to design sonic expression in a way that would spur the kids on to re-discover the already known park and to encourage them to engage with it. Most location-based games draw the player's attention to a predefined target location, and walking is a tiresome task that needs to be done to get there. In contrast, the aim in this game was to direct the player's attention to the present place and moment. An important concern in designing the game was to restrain from game rules that would impose time frames and thereby impact the players walking pace. While the park marked the walking area, no further regulations concerning the walking direction and speed was made.

Advancement of the translation schema

In this first prototype the basic concept was tested of using different sound streams, and respectively translation constructs, to represent the walker's activity. At this stage, the three sound streams were generated on the basis of independent walking processes: the player's geo-location, the player's walking movement and the game information. The study that was carried out with this prototype helped to interrelate these processes. The main contribution to the translation concept is a differentiation of the walking process by means of a walking vocabulary (see 4.5.1 *Walking Phrases*). This walking vocabulary was used by the subsequent prototypes to structure the sonic expression. More details on the sound design for this prototype can be found in Appendix C.1.

5.5 Design Case: Inspector Tripton

In this case the translation schema was applied in the context of an existing location-based game named *Inspector Tripton*[1]. The prototyping was conducted as part of a Bachelor project with students in the study program Media Informatics. The game Inspector Tripton is a single player game for the smartphone. In this location-based game, the player slips into the role of an Inspector who has to solve a murder case. To question witnesses and suspects and gather clues, the player needs to move to predefined locations in the real world which are augmented with virtual characters and pieces of evidence.

Walking setting

To play the game, the player has to move to predefined locations. The player's walking process can be divided into three phases: moving to a predefined location, finding the right position, and investigating at the location. It is not mandatory to walk and it is up to the player to decide which way to take to the next location. However, the distance between locations makes it reasonable to walk.

- Moving to game location: In this phase the player is on the way to one of the predefined game locations and can use the game map to navigate there.
- Approaching game location: This phase considers the periods when the player has to position himself into a specific radius around the predefined game location in order for game elements to become available for interaction.

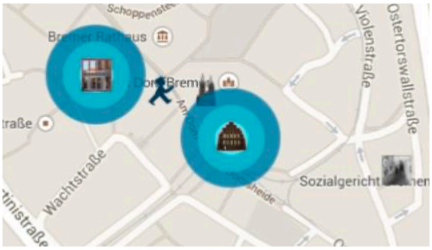
[1]The mobile game was developed by the software development company sprylab technologies.

- Investigating at game location: In this phase the player is interacting with virtual characters and objects at a game location.

Design Intention

In this type of game, the game world is not separated from the real world. Being in the mobile context, the player acts within the real-world frame, its conditions and conventions which entails that "Players create and recreate their game world while playing" (Grüter, Hajinejad, and Sheptykin, 2014, p.13). Consequently, a particular challenge for designers is to provide structures that support the player's immersion in the game world. The purpose of sonic expression in this case was to enhance the player's immersion into the game world and to facilitate the overall play experience. In the conceptualization phase the existing version of the game was playtested in Hamburg and the students defined two interrelated qualities to be supported through interactive sound: Firstly, supporting the player's identification with the role of the investigating inspector. Secondly, supporting the player's walking experience while moving inside the game world. Important for the *GangKlang* concept are the game phases *moving to game location*.

Together with the students, we developed a basic enhancement strategy for each of the three game play phases. In a Brainstorming session, we used the deck of Cards for Sound Design (developed by Alvez for Sound Design in Games (Alves and Licinio Roque, n.d.)) in order to inspire ideas for how sound could be used to support the play experience. Three types of sounds were most promising to be used: Ambience, Foley and Character soundprint. Moreover, the concept of Entrainment (Alves and Licínio Roque, 2010) was chosen as a general strategy to gradually accentuate and foreground selected aspects within the walker's experience.



(a) Illustration of game locations and player on a city map.

(b) Deck of Cards for Sound Design used in conception phase.

Advancement of the translation schema

In this prototype the player's walking process between two game locations was used as an example of walking in daily life. The walking vocabulary that resulted from the study with the previous prototype was used to structure the walking process. This structure then served as the basis for accentuation in the sonic expression.

Prototyping this design case was particularly enlightening in formulating a strategy for gradual accentuation of one sound stream (i.e. one walking aspect) in the sonic expression. This strategy emerged from the integration of three desired features: a) using semantic walking sequences of the player as input information, b) supporting the player's identification with the detective role while being on the way from one game location to the next and c) bringing variability to the monotonously repeating detective theme. To incorporate these features in design of interactive sound, the following strategy was implemented: when the player is on the way from one game location to the next the player's steps are used to trigger musical building blocks that gradually evolve into a detective theme. This way the player creates the detective theme with his / her own steps. The gradual development of the detective theme depends on the stability that the steps of the player gain while walking. A layering technique was used to enable this gradual evolution: a detective theme was designed and segmented into three layers, each made up of several building blocks. In the beginning of a walk-along phrase the player's steps will trigger the random playback of the basic layer of the detective theme. As the player's step frequency gains stability, the playback of the second and finally the third layer are triggered. This way, the exposition of a musical (detective) theme is used an expression of the player's walking movement gaining and loosing stability. As the musical theme gradually gains in prominence it also foregrounds the player's identity as a detective. To implement this strategy a further translation construct, named *Walk-Along* has been added. More details on the sound design for this prototype can be found in Appendix C.2.

5.6 Design Case: Flow-Maschine

In this case the task was to use interactive sound to enhance the user's ordinary walking experience. The idea was to counterbalance the predominant quantified-self design approaches that promote a utilitarian and rationalized perspective on walking. In this case interactive sound was designed with the purpose of re-emphasizing the bodily dimension within the walker's experience. To design for this kind of walking experience is about drawing the walker's attention to the present moment of walking movement itself and facilitating a sensual access to the embodied aesthetics of the activity. Like the first prototype this one was used in a later study. The details of the study and its findings are presented in the next chapter.

Walking setting

In the previous cases the user's walking process was more or less structured by the game context and this structure was used as a basis for interaction. In contrast, the goal of this case was to design interactive sounds in a way that allows walkers to experience sonified walking on any route at any time.

Design Intention

The goal of the sonic expression in Flow-Maschine is to orient the walker's attention to the present moment and to provide walkers a movement- oriented lens through which to experience the activity. Mediating walking through sound, we aimed to highlight the ephemeral and unique moments of the activity and re-prioritize walking aspects in favor of momentary ones.

Advancement of the translation schema

With this design case, the walking process was further differentiated. For this purpose, the detection component was extended with algorithms which allow the real-time detection of generalizable walking events (as defined in the study with prototype I). Furthermore, the strategy to develop a musical theme designed in the last prototype was transformed and further generalized so that it can be used for walking processes in everyday life. I use the term *Sonic Seduction* to refer to this strategy and elaborate on it in more detail in the discussion of the results. More details on the sound design for this prototype can be found in Appendix C.3.

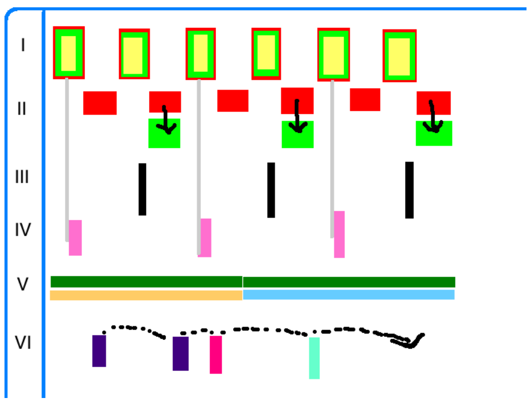


Figure 5.5: An illustration designed by the composer to describe the gradual unfolding of a musical theme over six layers.

5.7 Prototyping Results

The goal of prototyping was to substantiate the initially vague translation schema for the *GangKlang* approach. Three instances of the translation schema have been developed, each focusing on walking in a different setting. Over the course of prototyping translations, sonic material has been designed and algorithms haven been implemented to enable interactive sound for walking. The following section presents the translation design process in intermediate steps. Typical phases, related tasks and generalizable outcomes are discussed.

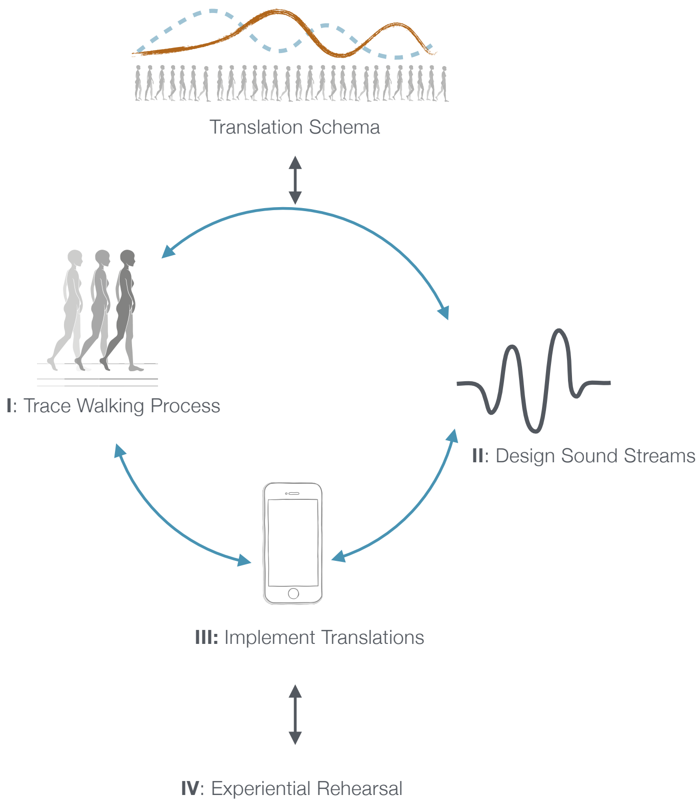


Figure 5.6: Overview on the phases and tasks in the translation design process.

5.7.1 Tracing the walking process

In all cases, the design of the sonic expression started with an intensive engagement with the walking process. The goal in this stage was to visualize the walking process and to describe it in a way that allows to empathize [2] with the different phases and moments. To this end, a description of the walking process is needed that highlights the important sequences and moments in the walking process.

For this purpose, I made use of storyboards and illustrations (see for example Figure C.1). This preparatory step helps the designer deciding which walking processes shall be expressed as sound streams in the sonic expression and their particular prominence. However, one difficulty here was to communicate the different simultaneously developing and affecting processes. Across the different design cases, it proved useful to dissect the walking process into three levels: the walker's body movement, the walker's relationship to specific places and prominent walking moments.

The first level concerns the movement of the basic walking movement (the gait cycle) and its changes such as slowing down, accelerating and perpetuation.

The second level describes the relationship to special places, the approximation, the entering into, walking within and leaving of special places. These places can be predetermined, as in design case *Inspector Tripton* where they are predefined by the game world. However, these places can also be generated dynamically by the individual walking behavior. An example of this is the generation of the target place as in the design case *Audio Game*. In the third design case *Flow-Maschine* the starting and ending of walking sessions as well as the recognition of turns was used for the generation of individual places.

The third level describes the walking process focusing on striking walking events. These events may mark the beginning and end of the other walking processes

[2] this phase comes close to the emphasizing stage in a design process.

or result from their interplay. In the first prototype, for example, the moment of entering the sweet spot was emphasized as a striking event. In the last prototype, stopping and turning into a street were chosen as striking moments.

The refined version of the description of the walking process is used later for the implementation of tracking algorithms. Previously however, the description is needed to design the sonic material from which the sonic expression will be composed.

5.7.2 Sound streams for walking

> *"To improve the aesthetics of our sonifications, then, we argue that first and foremost the designers of sonifications either need to be skilled in aesthetic thinking and practice or they need to work with someone who possesses such skills."*
>
> *(Barrass and Vickers, 2011, p.164)*

The question that guided this phase was: how does a particular walking aspect sound like? For instance, how does moving in the park sound like? How does stepping from one park section to another sound like? How does entering the sweet spot sound like?

Considering the design principles that have been discussed for the sonic expression of *GangKlang*, three considerations were important in this phase:

- The overall sonic expression, needs to be designed with regard to the particular walking setting and the intended frame of mind.
- The different sound streams need to harmonize but be distinguishable from each other at the same time.
- The characteristics of a sound stream need to correspond with the respective walking aspect. This applies above all to the envelope of

single sound elements in a sound stream.

In this stage, I have worked in a close cooperation with a composer (Ole Schmitt) to integrate the knowledge of a skilled musical expert. The description of the walking process that had been developed in the last phase (including sequencing and dissection) served as a means of communication between myself (as the interaction designer) and the musician and as a guideline for the composition to be designed. This template resembles the creation of the *cue sheet* in soundtrack production (MacDonald, 2017, p.24). The three-dimensional structure that has served in the previous phase for structuring the walker's activity was used in this phase to structure the overall sonic expression. The aim was to design a vocabulary of sound elements for each of the sound streams. The following steps were taken towards this goal:

1. A palette of sounds was selected together with the composer. The palette needs to be suitable with regard to the particular walking setting and the user group. Here existing musical pieces have been used as a guide.
2. Considering the different sequences and aspects of the walker's process, the composer than created a complete composition. It was important here that the composer makes use of the variety of musical expressions without limiting himself to the technical possibilities of the implementation afterwards. The composer engages with the question how sonic properties and musical structures can be applied to express the walking processes that have been described.
3. In the next step, the composer and I started to segment the sonic expression into chunks (building blocks). The building blocks had to address two demands: a) offer sufficient flexibility to be used in the interactive context and b) enable a musical composition including discernible melodies and harmonic structures, in order to accentuate selected sequences. How can the fixed composition be broken down into building blocks which, when dynamically put together by the walker's process, result in a musical composition? The following pattern has proved to be successful: using a

core sound event to sonify the walker's steps and gradually add further sonic building blocks to sonify other walking events of the walker's gait cycle [3].

4. A further step concerned the technical context. So, it was necessary to design sounds that can be played without losses or artefacts by the output device used in each case. In the design cases above the Apple iPod headphones were used and the attributes volume and frequency were usually adjusted after testing.

Throughout the three prototypes, and in analogy to the three walking levels, three generalizable types of sonic streams turned out to be useful to segment the sonic expression into. These sonic streams differ with regard to a) the types of sonic building blocks they consist of and b) the type of walking events they respond to. The second outcome is a strategy for gradually shifting the walker's experiential focus. Both outcomes help to map a connection between the purpose of the sonic expression in *GangKlang* (to facilitate the experience of the walking process) and the design of the translation.

Sonifying walking movement The sonic expression for the walking process and its change is the acoustic rhythm. Just as walking is a repetitive sequence of steps so is its sonic expression is a repetitive stream of sound elements. The envelope of the single sonic elements need to correspond to the physical repeating event. Concerning the sonic material, we incorporated in our prototypes drum sounds (Audio Game), real boot-sounds (Inspector Tripton) and marimba sounds. All of these sounds are compactly structured. In each case the percussive envelope of the sound reflected the physical impact of the foot hitting the ground and the timbre indicated the emotional quality and semantic context.

[3]For an overview on dynamic music techniques see (Collins, 2008)

Sonifying walking settings A setting is expressed by a number of sonic elements that are played in a well-balanced order to be perceived as an ambient background. The goal of the sonic stream here is to provide the user with a context by exploiting mainly the user's semantic listening mode. For our prototypes textural sounds with reverberation effects proved to be useful in order to create a background. In the first prototype this sound stream was used to represent the different park sections. In the second prototype the stream was used to reflects different game locations.

Sonifying walking events This sonic stream puts an emphasis on particular moments of the walking process and accordingly needs to be specifically prominent in the overall sonic expression accordingly. For this purpose, short sonic phrases are more suitable than single sounds. This streams refer to meaningful moments such as turning or stopping. The duration and dynamic of the sonic material used reflects the timeframe of the event and the timbre of the phrase denotes a certain emotional interpretation.

Sonic Seduction

The strategy for influencing the walker's experience is similar in all three prototypes. The vocabulary of walking movements used were selected in a way that keep the walker's natural movements unaltered. That is, only walking movements that are part of the activity were used as user input. However, to exert influence on the walker's experience a strategy named *Sonic Seduction* has been developed.

This strategy addresses walking sequences in which the walker keeps walking in a steady manner with a regular step length. In the last chapter, I have defined these sequences as walk-along phrases and associated them with reduced attention to the walking process (Section 4.5.1). Using *Sonic Seduction*, these monotonous phases are dramaturgically structured with the aim to initiate and sustain the walker's engagement with the walking process itself. Towards achieving this goal, we made use of musical themes that gradually evolve along the walker's successive steps and which assume shape depending on the steadiness of the walker's movements. The change of the sonic theme takes place on two levels. Firstly, the single sounds that are triggered by the walker's steps are changed. Secondly, the number of sounds that are triggered by one step event are increased or decreased.

5.7.3 Implementing translations

The iterative refinement of the translation structures went hand in hand with implementation of tracking algorithms in the Detection Component and translations objects in the Audio Controller. The algorithms enable to realize the conceptual decisions of the preceding phases and to generate the sound streams described above. The tracking algorithms provide information on the walker's activity process in real-time. The translation objects organize and trigger the playback of sound files. The following is a description of the two components.

Tracking algorithms

In accordance with the hierarchical three-layer structure of the walking process, three types of information are tracked.

The first type of information concerns the basic walking movement, that is the cyclic movement of two consecutive steps (gait cycle). A step detection algorithm tracks when the walker's left resp. right foot hits the ground. Further algorithms building up on the step detection inform on changes in the walking manner (e.g. whether the walker speeds up the pace) and walking events (e.g. the walker stops walking). The second type of information concerns spatial events. The algorithms provide information on whether the walker is inside a particular location. The question here is whether locations are predefined by the designer (absolute) or dynamically generated by the walker's behaviour (personalized). The third type of information concerns walking moments that are meaningful with regard to the particular setting. For example, in the first design case, entering the sweet spot is of particular importance for the overall playing activity.

Translation objects

The translation objects (T-objects) use walking information provided by the tracking algorithms to trigger and modify the sonic streams that have been designed in phase II.

For each type of sonic stream, a specific T-object has been implemented in order to account for the features needed. Thus there are three types of translation objects: *SoundEvent*, *WalkBeat*, *SoundCarpet*. Each T-object corresponds to a particular type of walking event. Moreover, a fourth T-object named *WalkAlong* was implemented to enable a time-based variation of the *WalkBeat* construct [4].

SoundEvent is the simplest T-object type and can be used to render the sound stream Walking Moment. A SoundEvent object holds one audio file, which will be played once with a volume that can be set by its parameter.

WalkBeat is designed to translate the walker's steps into the sound stream Walking movement (step sonification) and can hold a variable number of audio files. A WalkBeat can be assigned to the left or the right footstep and will trigger the playback of an audio file when a step is detected. The possibilities for ordering the available audio files are: a) always the same sound, b) rotation principle, c) random and d) playing one audio file and switching to a different audio file every designated number of steps.

[4] In the previous chapter, the term *Walk Along* was used to refer to steady walking sequences (4.5.1). The T-Object introduced here has the same name, however written in one word, as it was developed for these walking sequences.

Again a volume can be set, however, depending on whether the left or right footstep is assigned a panning effect is added so that the sound will be predominantly louder on the corresponding headphone side.

SoundCarpet is designed for the sound stream Walking Setting. It can hold a variable number of audio files. As long as a particular location is detected, playing the available audio files in a random order composes an ongoing sound stream. Through setting parameters of the object a pausing interval in between the audio files can be determined as well as an overall volume.

WalkAlong is designed for the state steady walking manner and allows changing the translation after a designated number of steps. A range of values can be set to divide the walker's continuous process of steps into different sequences. For each sequence an individual set of WalkBeats can be selected to sonify the left /right footsteps. Furthermore, an individual SoundCarpet can be selected for each sequence.

Walking aspect	Sound Stream	Translation Object
Walking movement (steps)	A repetitive stream of percussive sound elements.	WalkBeat
Walking setting	Textural sound elements layered and randomly played to create an ambient background.	SoundCarpet
Walking events (turn, stopping)	Short sonic motives that respond to walking moments.	SoundEvent
Walk-along (steady walking movement)	Sonic Figure that assumes by the walker's steps over a longer walking phase.	WalkAlong

Table 5.2: Refined Translation Schema: The walking process is described by means of three levels. Each level is linked to a Sound Stream with specific properties and implemented by means of a specific Translation Object.

Translation Object	Walking information	Parameters
SoundEvent (sound triggered once)	- Turn - Stopping	- One audio file - Volume
WalkBeat (steps sonified)	- Step (R/L)	- Audio files - Running order - Volume
SoundCarpet (location sonified)	Inside personal place	- Audio files - Pausing interval - Volume
WalkAlong (Walkbeat and Soundcarpet)	Steady Walk	- Sequencing values - WalkBeats - SoundCarpets

Table 5.3: Translation Objects translate walking events into sound and can be specified through parameters. The designer uses the Editor Interface to define T-Objects.

5.7.4 GangKlang Prototyping System

During the design process, it became apparent that sound and interaction designers need to experience from a first-person perspective the interplay of body movement, sound and mobile context. Acknowledging the designer's experiential awareness as an integral part of designing interactive sound, the mobile App was extended to a rapid prototyping system. The prototyping system supports provides a short design-experimentation-feedback loop and supports the design of interactive sonic expressions an iterative manner. This prototyping system enables designers to (a) specify the sonic response to a predefined set of walking movements in an editor interface, (b) use a mobile App to experience how their design for sonified walking unfolds in interplay with body movement in mobile situations, and (c) analyze process data that is collected by the mobile App to reflect on their sonified walking experience afterwards. The designer runs through three phases in each iteration cycle Table 5.4.

In the first phase, the designer uses an Editor Interface[5] to specify the sonic

[5]the desktop application has been developed by student Jendrik Bulk as part of his bachelor's thesis.

response to a predefined set of walking movements and states. In the second phase, the designer uses the mobile application (Mobile App) to experience how the sonic interactions that have been designed unfold while walking in-the- wild. In the third phase, the designer draws on process data recorded by the Mobile App during the walk to reconstruct, analyze and evaluate the aesthetics of the sonic interactions that have been designed.

	Phase I	**Phase II**	**Phase III**
Activity	Editing	Experiencing	Evaluating
Medium	Editor Interface	Mobile App	Process Data

Table 5.4: Phases in designing translations using the Prototyping System.

Editing

The Editor Interface is a desktop application that allows designers without programming skills to edit the sonic interaction mechanics of the Mobile App. The Editor Interface consists of a number of editing screens that enable the designer to specify the sonic interaction mechanics of the Mobile App in three stages: a) input audio files, b) create T-objects and c) link walking events to T-Objects. Firstly, the user inputs audio files to be played as sonic response into a sound library.

Secondly, the user creates T-objects (WalkBeat, Soundcarpet, WalkAlong), selecting sounds to be used and defining setting parameters. Thirdly, the user designs for a particular sonified walking experience using a mapping screen. In this screen the different the different walking events and states are listed and the user can connect each of them with a corresponding T- Object (Table 4). Finally, the user pushes a button to compile the sonic interaction mechanics for the Mobile App. Now, the designer can use the Mobile APP to experience sonic interactions while walking and to explore how the designed interaction mechanics unfold in mobile context.

Experiencing

The Mobile App can be used to experience sonified walking on any route. The user pushes the record button to start a walking session and will see a short tutorial that explains the correct usage of the App. In addition to putting on headphones, positioning and orientation of the smartphone in the user's trouser pocket is important to ensure a reliable detection of the walking movements; a further tab on a play button will start a counter. The user is given eight seconds to put the smartphone into the trouser pocket and start walking. After the countdown the App starts detecting the user's walking movements and translates these into sonic output in real time.

Evaluating

As the user walks with the Mobile App, various time- coded data streams are gathered and stored in log files on the iPhone. This non-intrusive caption allows designers and researchers to reconstruct and study the user's sonified walking experience afterwards. The sound composition that the user creates and hears while walking is recorded as an audio file. The walking events and states that have been detected during the walk are logged and each is marked with a timestamp. The GPS-positions of the user's walking route are logged. After the walk the designer (i.e. researcher) can download these files from the device and, for instance, listen to the sound composition that was composed by the walker's movements. For a more detailed analysis, the various data streams can be synchronized (e.g. using systems such as ChronoViz (Fouse et al., 2011)) to get a highly detailed account of the walking process.

5.7.5 Experiential rehearsal

> *"The multisensory aspects of interactive sonic experience that SID is concerned with must be designed with consideration of the orchestration of the auditory, tactile, visual, and kinesthetic senses within real-world context."* *Franinović and Serafin, 2013, p.xi*

The fifth and final phase essentially involves experiencing the implemented translation while walking in the mobile context and using the experiential insights to refine the implemented output of each phase. The questions guiding this phase are how does the sound feel like while walking? How does the sound feel like in the mobile context? The translation needs to be tested in the field to contrast the abstract idea against the particular experience. This phase is similar to the rehearsal period in the production of a theater play. The abstract script needs to be adapted to the concrete context. To understand the effect of the translation and to refine it to fit the intended design goal, the designer needs to experience the translation as it unfolds while walking in the field. In this phase, two types of refinement were typical: adjusting the sonic streams and reducing the overall complexity.

Adjusting sonic expression

Experiencing the interplay of hearing a sonic expression while moving the body resulted in refining. For instance, redesigning the sonic building blocks that are triggered by the walker's footsteps. How does walking feel like when your steps elicit percussive sounds (e.g. drum sounds) and how does it differ from when they elicit flat choir voices? The designer needs to explore, in an experiential way, how different acoustic properties affect the walking movement. Typical changes that were made during this phase concerned the pitch and duration of sounds. Moreover, experiencing sonified walking inspired to new translation ideas. For instance in the last design case, a panning effect was added to the sound that is triggered by the walker's steps to emphasize the relation of body weight from one feet to the other.

Reducing complexity

Experiencing the interplay of hearing the overall sonic expression while being in the mobile context has driven a number of adjustments. Typical changes were related to adapting the volume of sonic elements and reducing the overall complexity. This re-evaluation was due to the designer's experiential awareness for how walking in the mobile impacts attention resources. Another type of adjustment particularly addressed the design of location-specific sound. In the first two design cases predefined locations were sonified. Listening to the SoundCarpet while being at the location led to addition of new sonic elements and removal of other ones.

The implementation of functional prototypes is work-intensive, however the experiential awareness of the designer has shown to be a crucial resource for design and essential to gaining a better understanding for the interplay of sound, body movement and mobile context and contributed to the design. The necessity to account for a first- person perspective in the design process is increasingly recognized in the field of movement- based interaction design (Kristina Höök et al., 2018). To enable designers an experiential awareness for how their sound design unfolds in interplay with body movement in the mobile situation, a rapid prototyping system is needed.

5.8 Discussion Translation Framework

By prototyping, a translation framework named *GangKlang-Translations* has been developed for realizing the *GangKlang* concept and to embody its design intentions in concrete instances. *GangKlang-Translations* provides guidelines to support the design of sonic expressions that facilitates the experience of the unfolding walking process.

GangKlang-Translations		
Design Schema	**Implementation**	**Design Process**
Sound Streams rules to organize interactive sound in a sonic expression	**Translation objects** to trigger and modify sonic events based on walking information.	**Phases** typical phases and related tasks
Sonic Seduction strategy for gradually influencing the walker's experience		**Prototyping system** that enables non-expert users to design sonic expressions for walking and to experience their design in the real-world context

Figure 5.7: Overview on the three pillars of the framework GangKlang-Translations.

The concept comprises three elements to guide designers in creating interactive sounds to facilitate the walker's experience independently of the walking setting. The first element addresses the sonic expression to be designed. It includes guidelines to be considered in design of the sonic material and presents three types of sonic streams that proved useful for different walking settings. Moreover, the strategy *Sonic Seduction* (that makes use of unfolding sonic figures) is used for gradually influencing the walker's experience. The second element includes a set of translation objects that proved useful to implement the sonic streams that have been designed. The third element addresses the overall design method. It emphasizes the importance of an experiential first-person perspective in order to design for the interrelationship of mobile context, walking movement and sound and presents a prototyping system to support a first-person perspective in the design process.

The next chapter elaborates more deeply on the aesthetics of the *GangKlang* concept and explores how the resulting interactive sonic expression bears on walking experiences in daily life.

6 | Studying Sonified Walking Experiences

> *"... a designer can only set the stage for certain experiences to happen, but in the end, it is the user who constructs the experience with or through the interaction."*
>
> —K. Höök, 2008, p.

This chapter presents a qualitative study on sonified walking experiences within daily-life context. In the last chapter, a framework for designing a sonic expression to facilitate the walker's experience has been presented. How does this sonic expression bear on the experience of walking? To answer this question, the aesthetic impact of the prototype Flow-Maschine was investigated in an empirical study.

The chapter begins with laying out the approach to study walker's sonified experiences. In line with the activity-centered perspective of this thesis, the study is concerned with how people's experiences are embodied in the walking process. It follows a detailed description of the prototype with a focus on its sonic expression designed to facilitate the walker's experience of the unfolding walking process. Secondly, the study setting is described, followed by the process of data collection and the overall analysis method. Next, results are presented with a focus on the participants' experience of the sonic expression and their experience of walking movement.

Then, based on a single case, it follows a more detailed analysis of changes in walking movement in the different composition stages. The chapter ends with a discussion of the results with regard to the design objectives of *GangKlang*.

6.1 Approach

> *"When evaluating a new mobile service or application, it is critical to see how it is used in everyday contexts. This means conducting the field trial in as natural a setting as possible and over a time period in which use becomes more natural and less exploratory. "*
> *Bentley and Barrett, 2012, p. 112*

The goal of the study was to gain insight on how people experience sonified walking in real-life settings and the role of the interactive sonic expression on the walker's experience. This approach goes beyond studying isolated variables which have been studied in experimental studies (e.g. Turchet, Serafin, and Cesari, 2013). Rather, I seek to investigate how people experience interactive sonic expressions that evolve in everyday walking circumstances. And more specifically, if the interactive sonic expression can orient the walker's experience to the walking process itself in daily life context. To this end, I conducted a two-week comparative study. In the first week, the participant's used the Flow-Machine prototype on an individual route of their daily life, without, however, hearing any sonic feedback. In the second week, they walked the same route while hearing the interactive sonic expression.

Field trials are particularly suitable for understanding mobile experiences (Bentley and Barrett, 2012) as dynamic and unpredictable conditions are constitutional to the experience (chapter challenges). Semi-structured interviews were selected as a method for collecting subjective data before and after the sonified walking experience. In addition, automatically captured logs were gathered in order to gain a close-up lens to the walking process without interfering. In the following, I describe in more detail the specific prototype that was used in this study.

6.2 Prototype

The prototype was designed to be used by participants in their daily life routines as a counterbalance to predominant quantified-self design approaches. The objective of the Flow-Maschine Prototype is to foreground the experiential qualities of the walking process itself. The interactive sounds in the prototype are tailored towards re-emphasizing the bodily dimension within walker's experience.

To start the sonified walking, the user starts the app and tabs on a record button on the start screen. Now, a short tutorial visualizes the correct usage of the app: in addition to putting on headphones, the positioning and orientation of the smartphone in the user's trouser pocket is important to ensure a reliable detection of walking movements; a further tab on a play button will start a counter. The user is given eight seconds to put the smartphone into the trouser pocket and start walking. After the countdown the walking-to-sound translation as well as the collection of data to be used in the analysis. We chose a set of calming musical sound, all in one key, to provide a sonic expression without dissonance. The following scenario of a walker named Mary will illustrate the use of the mobile application and the resulting sonic expression.

6.2.1 Scenario

Mary steps outside, having a smartphone in her pocket and headphones on. She starts walking. She swings her body's center of gravity from one foot to the other. As her right foot touches the ground she hears a short marimba sound (minor second) on the right ear, as her left foot touches the ground she hears a marimba sound on the left ear. At first, her step intervals form an irregular pattern of sounds, but as she continues walking, the rhythm of her steps and accordingly the sounds become more regular. Mary starts to experiment and accelerates her steps and the marimba tones accompanies every step but alternating now between two pitches. As Mary slows down, each step is accompanied by the same marimba pitch again. As Mary stops walking, the marimba sounds disappear with a reverberating effect, as she starts moving, so do the marimba sounds. She continues walking and reaches the end of her street. While turning left into the main street she hears in addition to the marimba step sounds a vibrating sound motive that pans from the right to the left ear and blends out again. Mary continues her walk and as her steps become more regular a further sound, a short bass tone, starts to accompany the marimba tone of every second step and changes between two pitches. After some seconds the set of bass pitches is extended and shifts in a fixed order between four different pitches. By now a beat accompanying Mary's walking rhythm has evolved. Some seconds later, a spherical sound blends in, joins the rhythmic beat of Mary's steps and evolves into a continuous sound carpet. Little by little, the percussive composition turns into a spherical one, as the step accompanying marimba sounds become more and more quiet, to the point where they are no longer perceivable. The same happens with the bass sounds. And after some time even the spherical sound carpet thins out and blends into silence. Mary is surprised but continues walking and some seconds later the marimba sounds start accompanying her steps again [1].

6.2.2 Application of Sonic Seduction

The design of the sonic expression in this prototype incorporates the strategy of *Sonic Seduction* as described in the previous chapter (5.7.2). In this case the strategy is used to repeatedly draw the walker's attention to the process of walking movement itself. When the walker's stride becomes steady the sounds that respond to the walker's steps change gradually over a period of 200 steps from percussive marimba sounds to spherical synthesizer sounds to silence (40 steps). This way, enduring walk-along phrases are aurally structured

[1] I recreated this walking scenario using the mobile application. The resulting sonic expression that was generated and recorded by the app can be listened to using this link: https://www.youtube.com/watch?time_continue=32&v=yaTaYjIocvo&feature=emb_logo

in composition cycles. Each composition cycle includes nine stages which can be divided into three phases, percussive, spheric and silence (See Figure 6.1).

Figure 6.1: As the walker keeps walking with a steady stride the sonic expression changes over a period of 200 steps from percussive to spheric, to silence. This cycle repeats as long as the walker continues walking with a steady stride. An animation illustrating the dynamically evolving composition can be seen here: https://youtu.be/3dL7Ay8pJfs

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6.3 Study Design

Eleven individuals, eight female and three male, between 26 and 36 years old participated in the study. Only participants with no computer science background and regular walking routes of approximately 15 min. duration were recruited. Two type of data was gathered:

- subjective reports on the walking experience were gathered by audio recording three semi-structured interviews,
- and objective process data was collected by recording various data streams with the app while participants were walking.

The study was divided into two weeks, each week having its own focus. We conducted an individual semi-structured interview at the beginning of the study, after the first week, and after the second week. In the first interview, the participants selected a walking route for the study, based on destinations they regularly visit, preferably twice a week, for example a route between their home place and a nearby supermarket. This way, we ensured that participants would experience the sonic interactions on a familiar route and within their daily walking routines. In the first week, in order to gather baseline data, we provided participants with a data collection application and told them to track their data whenever they walk on the study route. In the beginning of the second week, we conducted a second semi-structured interview and provided participants with the sonic interaction app. We showed participants how to start the app and how to position the smartphone in their pocket. Participants were not introduced to the particular sonic interactions. We then told them to use the app whenever they walked on the selected route. The study was finished with a third semi-structured interview after the second week.

Overall, 89 walking sessions were collected, including 49 sessions without audio feedback and 40 sessions of sonified walking. The duration of the walking sessions varied from 12 to 26 minutes.

In one case, the iPhone was placed loosely in the walker's trouser pocket so that the correct detection of walking movement and according audio-feedback could not be provided. Excluding this participant's data, interviews and process data streams of eleven participants walking on different routes was gathered after the two weeks.

Phase	Description	Data Collection
A: Interview I	At the start of the study all participants were provided with an iPhone 4S and individually interviewed. In the first part of the interview, participants were questioned about their daily places of destination. One destination within walking distance was selected for the study. In the second part of the interview the use of the mobile application was explained.	Audio recording of interview
B: Baseline week	Participants used the mobile App (audio feedback deactivated) to record their walking activity on their way to and from the selected destination place on two different days.	Real-time data capturing
C: Interview II	In individual interviews, participants were questioned about their impressions and experiences on walking with the mobile App. Afterwards the audio feedback of the app was activated. Participants were provided with headphones and instructed to wear them when walking with the App. Participants were not informed on the rules used to enable interactive sound.	Audio recording of interview
D: Feedback Week	The participants used the mobile App on two different days to walk to and from their individual destination place.	Real-time data capturing
E: Interview III	In a final interview, participants were questioned on their impressions and experiences of sonified walking.	Audio recording of interview

Table 6.1: An overview on the individual phases of Study B and data collection in a chronological sequence.

6.4 Analysis: Subjective reports

To analyze the impact of *GangKlang*, I took an explorative approach and organized the collected data accordingly in the process of analysis. I started the analysis with the subjective reports that were recorded in phase E. These reports were collected after the second week, when the participant had experienced sonified walking. The analysis focuses on two aspects: a) how does the participant describe the dynamic sonic expression; and b) how does the participant describe the sonified walking experience in the second week and in comparison to the walking experience in the first week (without sonic feedback).

In a qualitative analysis of the interview data, I used the affinity technique in the following steps:

1. A profile for each participant was created, including key information on the individual walking context. This profile is later used as a reference frame in the interpretation of the data.
2. All statements concerning what was heard, thought and felt were transcribed.
3. The quotes were color-coded according to the individual participant.
4. Repeatedly used descriptions were clustered to identify shared themes.
5. Each theme was elaborated with a focus on similarities across the participants' narrative accounts.

In the following, shared themes concerning a) the sonic expression and b) the walking experience will be presented and illustrated with quotes. All names of participants were anonymized, while the gender was retained. The transcripts of these interviews are included in Table B.4.

6.4.1 On the sonic expression

In the last interview seven participants (63%) used the term *music* to refer to the sonic expression and two more used it only once. Concerning the sounds, seven participants (63%) described the sonic expression as “relaxing”, “meditative” or “pleasing”, and a further one said she had to yawn all the time as the music made her “weary”.

Eight participants (72%) recognized a correspondence between the sonic expression and their walking movement, while one participant was not sure about it. In particular, participants recognized their walking rhythm to be reflected in the sonic expression. The following quotes illustrate the way participants described this interdependence:

- Lucy: “the rhythm [of the sonic expression] is in the rhythm of my walking”
- Miles: “a xylophone in step mode”
- Kyra: “as if I was walking on high heels”

Describing the sonic expression, seven (63%) participants distinguished between rhythmic and melodic sequences. Dan reported on the gradual change in the sonic expression as follows: “Single sounds in the beginning and then it became sequentially more fluent, evolving to a melody”. Miles described this transition with these words: ”Alongside, there were low-pitched sounds that integrated into a melody“.

Six participants also reported on user-independent parts of the sonic expression. Most of the statements made here referred to the silent phases as the following statements demonstrate:

- Tom: "it’s not completely dependent on what I do"
- Vera: "when I didn’t walk anymore it became quiet but there were also breaks at other times"

- Anne: "in between it also interrupts"

6.4.2 On sonified walking

The participants were asked to compare their experience when walking with and without sonic feedback. Nine participants (81%) mentioned that sonifed walking had an attention shifting effect.

Sue describes that the sounds reacted to her walking manner and exemplifies this with sounds fading away when she stopped walking and changing when she turned left or dodged other people. She continues saying that “and this was interesting, because it [the reaction] made me walk more consciously, though it did not judge”. A similar remark is made by Lucy: “By hearing something that adapts to it...to my movement in some way...that it makes me feel more with myself...and somehow directs my attention to it". Anne said that without feedback she was “somewhere else with my thoughts and I didn’t even think about walking anymore”. However walking with feedback “I’ve been pulled out of this thinking process over and over again." She found the repeated refocusing on the walking movement disturbing as that she was annoyed as the feedback and its changes made her pay attention to the own movement and this way walking felt more "conscious" and "exhausting".

Dan emphasized differences regarding his thinking activity. He points out that in the first week when walking without feedback he was thinking a lot about upcoming journeys and his work but “with the music it was somehow different ...this melody, I don’t know, has guided one”. Kyra makes a similar same point. She said that usually she does not like walking “the distance is quite dominant in my perception”. She knows the route quite well and would think “oh god, I have to go all the way again [. . .] but with it [the sonic expression] walking was ok” and that she had “fewer debates in my head”.

One participant expressed her surprise, realizing after the walking session that she did not hear the church bells at the full hour, although the sonic expression was not loud.

Five participants (45%) particularly mentioned that the shift to silence within the sonic expression interrupted their attention focus, either pulling them out of their thoughts or allowing them to get sunk in thoughts. The following quotes illustrate this.

- Miles: “Brought back to the present”
- Dan: “Thinking more during pauses”
- Kyra: “A vigilance in the silence, attentive listening”

All participants were convinced that the sonic expression did not influence their walking movements. Nevertheless, six participants (54%) made remarks on an altered experience of walking movement.

Kyra points out that usually she drags herself to work but with the interactive sound she “felt more energetic... like you just had coffee... I was walking briskly”. Tom said he is wondering why he felt like walking faster, even though the sounds were calming. And that he compared the time and was actually not faster than the week before when walking with no feedback. By contrast, Bonnie said that "I actually felt slower with the music, maybe because I was relaxed".

6.5 Analysis: Objective process data

The majority of the participants reported on a structuring effect of the sonic expression on their attention focus. More specifically, participants related this effect to the sonic composition cycles (that divides enduring walking-along sequences into sequences of 200 steps). At the same time however, all participant assured that the sonic expression had no influence on their walking movement. In a further analysis, I focused more closely on the effect of the composition cycles on a participant's walking movement. Here, I used the walker's movement data that had been tracked and stored by the application. Here, I particularly focused on changes of the gait cycle duration (stride duration), as previous research findings suggest that stride duration can be influenced by sonic feedback Chapter 2. Existing studies show that body movement can be modulated by the envelope of sound events. As presented above, the sound events that are triggered by the walker's steps changes within a composition cycle from percussive sounds with a short envelope to melodic sounds with a long envelope. The assumption was that this change in the sonic properties would affect the walker's movements. The question guiding this in-depth analysis was: *Does the recurring composition cycle correspond with a recurring change in the walker's movement data?*

I followed an abductive approach to investigate the influence of the composition cycles on the walker's movement. The first step was to find a suitable case for the analysis. Towards this goal, I selected walking sequences in which participant keep walking in a steady manner for more than three composition cycles (that is for more than 600 steps). I then focused on a particular case, a prominent walking session with the longest walk-along sequence. I use my observation and interpretation of this particular case to formulate a general rule (hypothesis) for how the composition cycle influences the walker's movement. In the following, I will first introduce the selected walking session based on the respective interview. This information provides a frame for understanding the specific walking session. I then present the calculations that I applied to the walking movement data, the results and finally my interpretation and reasoning of the results.

6.5.1 Walking case

The female participant Vera used the Flow-Maschine app on her walk to and from her meetings with her choir group that she used to visit twice a week. The route has a length of approx. two kilometers and participant V. covered the distance in about 20 minutes. The walking sequence that I selected for the in-depth analysis belongs to the fourth (i.e. the last) walking session of the participant. This walking sequence starts at second 292 and ends at second 903 and continues over a period of six sonic composition cycles (see Figure 6.3). Interestingly, the participant highlighted this session as particularly positive in the follow-up interview. While in the walking sessions before she had been elsewhere with her mind, in this session she was more "in the sounds": "there [session 4] I was again more in it, in the sounds...what did I think of yesterday [asking herself]... I liked it very much on my way home, but I don't know why".

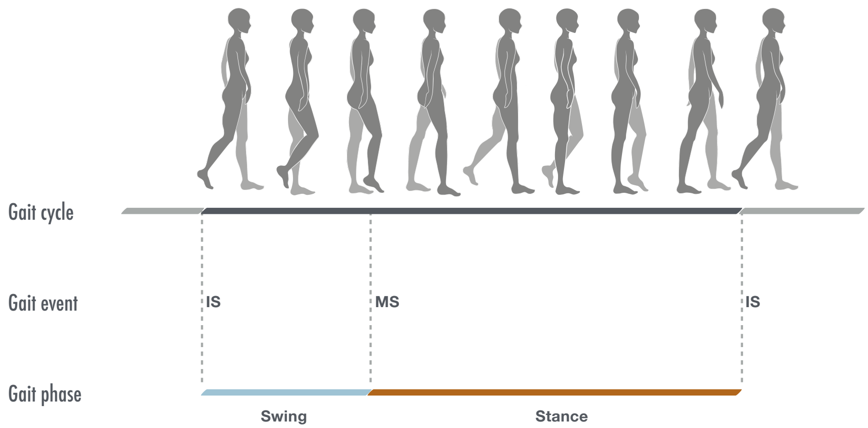

Figure 6.2: Illustration of foot movement during a gait cycle and the gait events *Initial Swing* (IS) and *Mid Swing* that have been tracked by the app.

6.5.2 Analysis of walking movement

Observations regarding changes in the walker's movements are dependent on a reliable detection of gait events. Figure 6.2 illustrates the gait cycle and the gait events *Initial Swing* (IS) and *Mid Swing* that were tracked[2] and stored with their according time stamp by the application. These two events were chosen

[2]The details of the tracking algorithms implemented can be found in the doctoral thesis of Simon Bogutzky (Bogutzky, 2017, p.90)

as they can be easily detected from the raw motion signal of the iPhone[3]. The interval between two gait events of the same type can be used to calculate the duration of a gait cycle, named stride duration (Murray, Drought, and Kory, 1964). The interval between two consecutive gait events *Initial Swing* and *Mid Swing* can be used to calculate the duration of the gait cycle phase *Initial Swing phase* which starts with the lifting of a leg from the ground and denotes the first section of the same leg's swing phase. I used the software Observer[4] to get an overview on the selected walking sequence by means of the multi-modal data streams: the walking events that have been detected and the dynamic sonic expression that was played (see Figure 6.3).

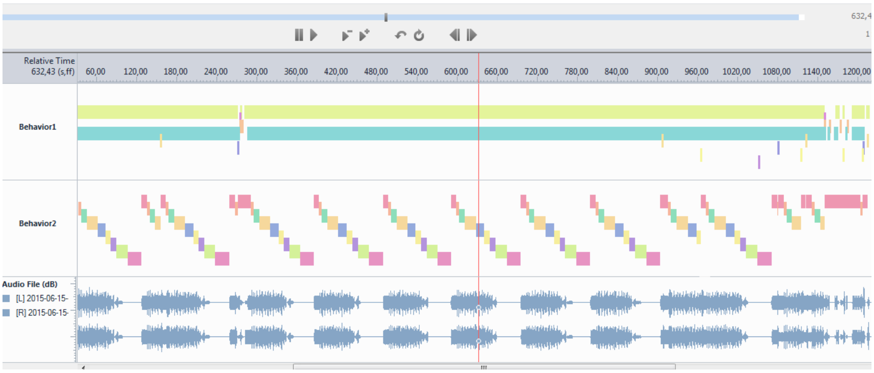

Figure 6.3: Screenshot of data streams visualized with Observer. The selected walking sequence is displayed by three data streams. The first stream 'Behaviour1' visualizes the gait events initial swing and mid swing. The second stream 'Behaviour2' visualizes the change of the sonic expression according to the nine stages of the composition. The third stream is an audio recording of the sonic expression.

[3]The iPhone was carried in the user's pocket when using the application. To track the user's walking movement, we used the forward movements of the leg (A) on which the iPhone was carried. We used the event Initial Swing to calculate the moment when foot (A) hits the ground and the event Mid Swing to calculate the moment when foot (B) hits the ground.

[4]https://www.noldus.com/observer-xt

Next, I used the programming language R to prepare the two data streams walking events and sonic composition stages for the purpose of visual inspection. The R programming language [5] allows to create individual data visualizations and to carry out statistical calculations. Together with the help of the student assistent Philipp Marsch, I implemented an R-program with algorithms to visualize the change of the walker's stride duration in relation to the composition stages for a given time period.

The R-program provides algorithms for two type of plots. The first plot shows a time series graph (see for example Figure 6.4) that visualizes changes of gait cycle duration (y-axis) and the composition stages (from zero to nine) that the participant was listening to in this time period (x-axis). Each composition stage is illustrated in a different color for visibility purposes. A spline is plotted to help identifying trends in the gait cycle duration. The second is a box plot that allows to compare the gait cycle duration in the different composition stages. In Figure 6.4 the selected walking sequence is segmented into individual composition cycles providing a focus on how gait cycle duration develops in relation to composition stages in each cycle.

6.5.3 Results

In the visualization of the data streams in the Observer software (Figure 4.3), we see that the gait events have been detected alternatingly and that no turns or stopping events (that is significant changes in pace) have been detected in this walking sequence. Due to the frequency of detected gait events we can presume a reliable step detection in this walking sequence.

As we see in the time series graph Figure 6.4, there is an upward trend of stride duration in this walking sequence. Taking a closer look on how gait cycle duration changes in relation to the composition cycles, we can see that local minima appear along percussive stage (blue) and local maxima appear

[5] https://www.r-project.org/about.html

along melodic composition stages (red). Comparing the composition cycles Figure 6.5, we can see that in five of the six cycles (1,2,3,4,5) the walker's gait cycle duration increases from the percussive composition stage two to the beginning of the melodic stage four. Further, we can see that in four cycles (1,3,4,5) the gait cycle duration decreases from composition stage four to stage seven.

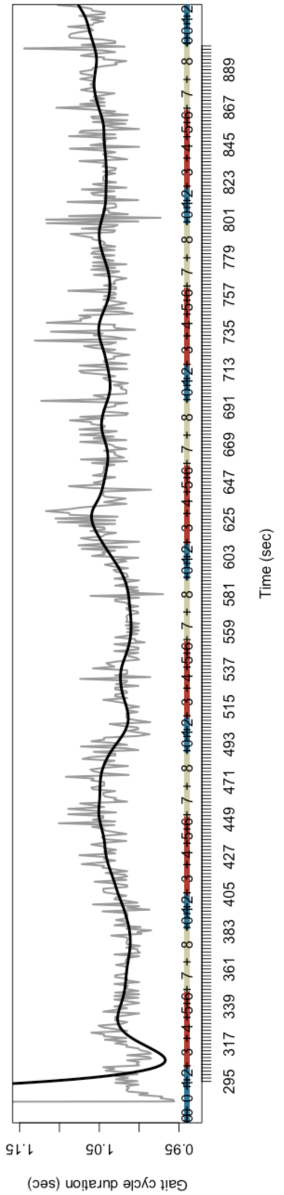

Figure 6.4: Time series graph showing the change of stride duration along the sonic composition.

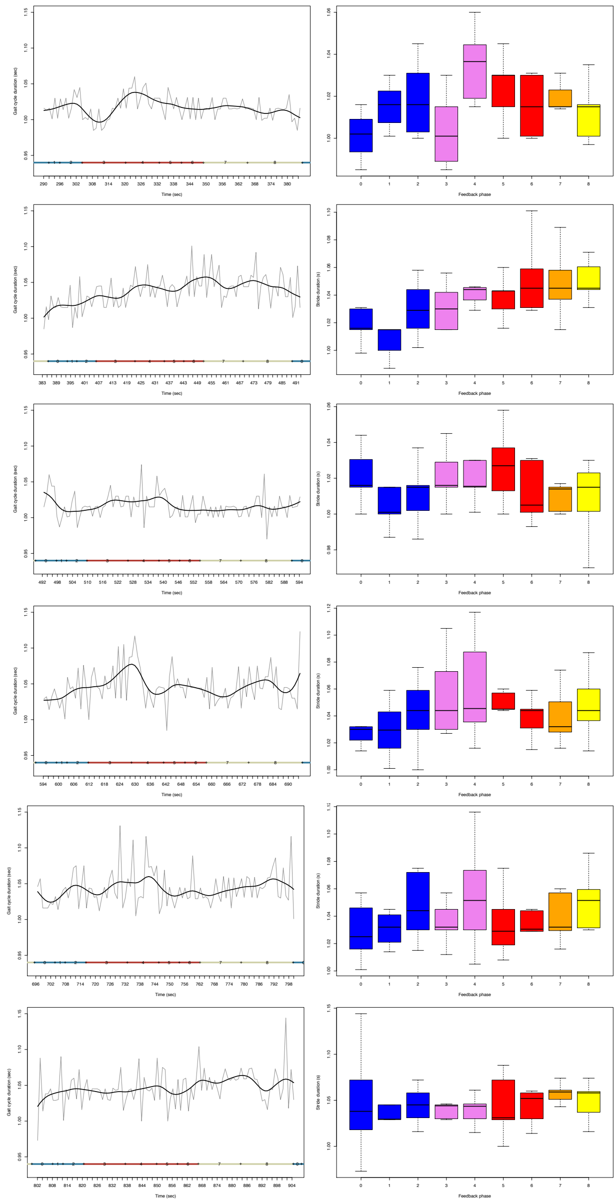

Figure 6.5: Time series graphs showing the change of stride duration along the sonic composition.

6.6 Findings

In general, participants perceived the walking soundscape as some kind of "meditative" music with a psychologically calming effect. Most participants recognized a correspondence between the heard sonic expression and their walking movement. Participants were not explicitly asked to report on attention focus. Remarkably, nine participants (81%) mentioned *a shift of attention towards self and walking process* as a striking difference when walking with the interactive sonic expression.

By design, enduring walk-along sequences were structured by composition cycles into sequences of 200 steps. This sonic structuring influenced the walker's flow of thoughts (e.g. rumination), redirecting their attention to the present moment. Interrupting behavioral routines has been discussed as an important challenge in designing for behavioral change (Laschke, Diefenbach, and Hassenzahl, 2015). The findings indicate that interactive sound has the potential to interrupt behavioral routines. In addition, participants reported that the sonic expression had a positive effect on their thoughts and an energizing effect on their body movement. Similar qualities have been reported to characterize the experience of work while singing work songs (Wolterstorff, 2015). The reported experience of altered time perception may be explained by strong immersion (Sanders and Cairns, 2010) and is used as a determinant of flow experiences (Csikszentmihalyi, Abuhamdeh, and Nakamura, 2005).

Interestingly, although most participants mentioned an influence of the sonic expression on their focus of attention, they were sure that their walking movement remained unaffected. In a further analysis, I focused more deeply on the structuring effect of the sonic expression on the walking movement.

On the whole, the walking data considered in the in-depth analysis indicates that the participant's walking movements have evolved in accordance with change in the sonic composition cycles. Changes in the walker's stride duration occurred repeatedly along specific composition stages. In average, the walker's stride duration has lengthened in the transition from percussive to melodic stages of the composition (in which sustaining melodic sounds are added to the percussive step sounds). In addition, the walker's stride duration has shortened in the transition of the composition to the silence stage. These results confirm the assumption that the compositions cycles had an effect on the walker's movements. The change in the walker's stride duration running in parallel to the composition stages can be explained by an adaptation to the properties of the sound events that are triggered.

In particular, the extension of the stride duration in transition from the percussive to the melodic composition stages can be explained by the fact that the participant has adapted her walking movement to the envelope of the triggered sounds. Both the participant's subjective statement of "more in it, in the sounds" and the synchronization of her movements with the composition stages point to an embodied involvement with the sonic expression. Interestingly enough, this refers to a session that the participant highlighted as particularly positive. This strong involvement in turn provides an explanation for why the participant experienced this walking session as particularly positive.

6.7 Discussion

The analysis concentrated on sonified walking experiences in daily life. The aim was to evaluate the *GangKlang* concept and to examine whether the translation structures that have been developed are suitable to support the experience of walking as self-contained activity.

The results presented above confirm our assumption that an interactive sonic expression can be used as a means to influence the walker's experience in daily life. The results show that the strategy of unfolding sonic figures is suitable to bring about a refocus on the walking process and align with the initial design intention to support the walker's immersion into the walking process. Furthermore, the results confirm our assumption that a design which strengthens the experience of the activity process (instead of concentrating on the outcome of the activity) can have a positive effect on the experience of the daily activity. With the exception of one participant, everyone rated the refocusing on the walking process as positive. However, this individual case shows that refocusing on the body movement can also emphasize the effort of the physical activity.

7 | Conclusion

> *"This regular movement becomes even more pleasant when it is rhythmically accented, which is to say, when there is a small differentiation in strength and weakness between each step or beat, wherein continued variety may be attained. [...] This measured motion can be easily joined to a series of musical sounds, since musical sounds themselves always imply an idea of movement. Such is the origin of rhythmical songs and the dance."*
>
> — Sulzer, 1996, p.82

In this chapter, I reiterate the main findings of the thesis by answering the previously introduced research questions. Further, the research-through design method used for developing the overall *GangKlang* concept will be discussed.

This chapter ends by highlighting some of the findings that I consider to be particularly relevant to the field of research. Based on the these, suggestions for designing for experience of everyday activities are given and questions are raised for further research activities.

7.1 Answering Research Questions

This thesis took the prevalence of interactive systems and how they permeate our daily activities as grounds to investigate how they can be designed to facilitate the experience of daily activities. The majority of applications for walking follow a quantified-self design approach and provide the user a lens that foregrounds utilitarian aspects and quantitative outcomes of the activity. However, psychological studies suggest that drawing attention to output might diminish the enjoyment of an activity and undermine people's motivation. In contrast, the concept of flow emphasizes that positive experiences emerge when a person is fully engaged in the activity itself and doing it for its own sake, regardless of its outcome.

Taking this gap into account, I have introduced an alternative approach for designing interactive sound for walking: *GangKlang*. The main characteristic of this approach is that walking is designed as a self-contained activity. The *GangKlang* concept focuses on supporting the walker's experience of the unfolding process; independent from motives and goals. This process-centered approach runs contrary to goal-oriented ones that predominate the design of quantified-self applications. I studied the challenges posed by the *GangKlang* concept to the design of interactive sound. I formulated requirements for interactive sound design and worked out design solutions by prototyping. Finally, I investigated the effect of interactive sound that is designed according to the *GangKlang* concept on the walker's experience (See Figure 7.1).

The explorations of this thesis were guided by the overarching question:

> *How may we design interactive sound for the experience of walking as a self-contained everyday life activity?*

In Chapter 2, I highlighted key factors that are constituent for the walker's experience in any situation and need to be considered in design of interactive sound: the mobile context, the walker's body movement and the experience of sound. Thus, I framed the challenge in designing interactive sound for walking experiences in daily life as interrelating and integrating these factors that mutually influence each other. I discussed the concept of activity as one that focuses on the inner connection of external and internal processes and approaches subjective experiences on the basis of the external activity process. I proposed the activity structure as an appropriate framework to organize and relate the various factors that play a role for the walker's experiences.

In Chapter 3, I analyzed design examples of interactive sound for walking in order to answer the first sub-question:

> *Which choices in design of interactive sound set the course for the walker's experience and what are the requirements to design for walking as a self-contained activity?*

I compared experience-oriented applications and the decisions they implement in design of interactive sound to move different aspects of the walking activity into the walker's experiential focus. The examples have illustrated the various perspectives from which the walking process can be described and how this perspective is implemented by selection of tracked walking data. Furthermore, the examples illustrated the range of sonic attributes by means of which a particular reading of change in the walking process is suggested.

However, the analysis also shed light on the dependency of the design decisions from the predefined walking setting. These examples draw on predefined settings and presumed walking goals to make decisions about the walking data that is tracked and to select the dynamic sonic parameters that change along the walking process. Thus these examples promote walking aspects that are specific to a predefined setting. This analysis allowed me to identify two experience-directing tasks and related decisions in design of interactive sound: the translation of walking activity to a process model and the translation of the walking data into a sonic expression. Building on this, I specified requirements for implementing the *GangKlang* concept. To promote the experience of walking as a self-contained activity, a process model is needed that is based on factors that are inherent to walking and derives relevant contextual information from the unfolding walking process itself. Further, a concept for translation into a sonic expression is needed that meets two requirements: a) providing constructs to sonify basic walking dimensions while considering their mutual interplay and b) providing constructs that foreground the walking process.

The details on how these requirements can be realized have been investigated in the subsequent chapters 4 and 5. Through the iterative design, development and deployment of prototypes, I answered the second sub-question:

> *How may we take choices in design of interactive sound to facilitate the experience of walking as a self-contained activity?*

The question relates to the requirements outlined above and has been answered by appropriate modelling and translation concepts.

In Chapter 4, a solution to meet the first requirement has been presented. I developed a walking model based on the walker's movement process: *Walking Phrases*. In this model, contextual information is derived from the cyclic walking movement and its changes in the process. *Walking Phrases* allows, without predefined setting information, to adapt sonic feedback according to the walker's attentional resources and to determine emerging places. This way, the model provides for a setting-independent design of interactive sound.

In Chapter 5, a solution to meet the second requirement has been proposed. Based on structures that proved useful to sonify the walking activity in different settings, I developed a concept for translation which allows to design interactive sound for walking as a self-contained activity. The concept comprises three elements. Firstly, translation structures to sonify the basic dimensions of the walking activity. Secondly, a strategy of *Sonic Seduction*, where the gradual change of triggered sounds is used to design the dynamics of the sonic expression and thereby to strengthen the experience of the walking process. Thirdly, the concept includes a methodical approach for using the translation structures in the design process and to implement particular instances of interactive sound for walking. The elements of the concept are embedded in a prototyping system to support the design process.

In Chapter 6, the third prototype was used in a study to evaluate the design solutions that have been developed for the *GangKlang* concept. The study focused on the question:

> *How does the* GangKlang *approach bear on the walker's experience in daily life?*

The prototype was used by 12 participants on individual everyday routes. The analysis concentrated on the suitability of the *GangKlang* concept to facilitate the experience of walking as self-contained activity. The results show that the strategy of *Sonic Seduction* is suitable to bring about a refocus on the walking process. Furthermore, the results confirm the assumption that a design which strengthens the experience of the activity process (instead of concentrating on the outcome of the activity) can have a positive effect on the experience of the daily activity.

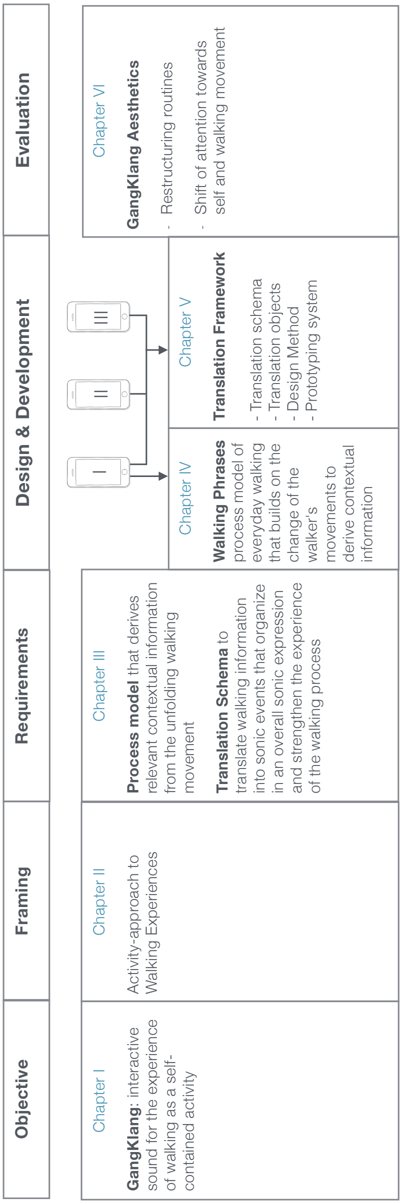

Figure 7.1: Schematic representation of the concept GangKlang, its implementation and evaluation.

7.2 Reflection on Methods

The objective of formulating the *GangKlang* concept, confronted me with the challenge of simultaneously illuminating two broad topic: the design of interactive sound and the experience of everyday activities. Both the design of interactive sound as a medium and everyday experiences can be approached by an infinite variety of perspectives and concepts. I have applied a research-through-design approach to study the fabric underlying the interplay between the design of interactive sound and experiences of everyday walking. In particular, I used the iterative development of prototypes to express, concretize and formulate an activity-centered approach to interactive sound design.

In this approach the prototypes worked as 'epistemic artifacts'(Richter and Allert, 2011) that allowed me to express and concretize ideas, they "served as definitions made through design" (Kristina Höök et al., 2018, p.3). This approach has proven its worth in bringing together the multitude of interdependent decisions at the core of the work instead of investigating individual questions in isolation. The prototypes confronted me with the task of reconciling and applying the most diverse pieces of scientific and design knowledge with regard to the design goal. Johl Kolko describes this process very nicely with: "a way of organizing complexity or finding clarity in chaos." (Kolko, 2009, p.1). In the process of solving this task missing connection pieces became clear. This thesis was particularly concerned with relating knowledge about the structure of everyday activities to the design and organization of interactive sounds. As a result, concepts and models have been developed to explain how these pieces of knowledge can meet and how they can be used in design.

Implementing the conceptual decisions and developing prototypes of interactive sound for walking is very time-consuming and was only possible in cooperation with programmers and a composer. The programmers focused on the implementation of algorithms to detect gait characteristics in real-time. The composer provided sonic material and has contributed with his knowledge to create melodic patterns and themes. The various tests that were necessary to work out single technical features and to refine sonic material have not been discussed here in order not to lose focus. The collaboration with the composer was especially interesting as two different ways of shaping sonic expression met here. The composer is used to structure time. In contrast the interaction designer works on rules and conditions in order to create possibilities for sonic expression to emerge.

Doing research-through-design on an interdisciplinary subject matter affords specific documentation and representation possibilities that enable a common understanding of the interaction mechanics, dynamics and aesthetics created . Focusing on the role of documentation, Bardzell et al. have triggered a discussion on the role of documentation in RTD projects and state "that documentation is itself an act—an RtD act" Bardzell et al. (2016, p.105). In cooperation with developers and composers, we have created visualizations and animations to represent possible walking scenarios and resulting sound expressions[1]. One difficulty here was to develop a notation system that is understandable for all team members (Seibert and Hug, 2013, see e.g.). The notation system needs to represent individual sound events as they are triggered by the walker's movements, their modification as well as the sound patterns (melodies) forming above them (i.e. the single mechanics and emerging dynamics of interactive sound). As R. Murray Schafer points out, the notation of sound events is a particular problem of the subject: "Beyond aural perception is the notation and photography of sound, which, being silent, presents certain problems" Schafer (1994, p.8). I did not systematically work on a notation system as this was beyond the scope of this thesis. However, I created animations in the last prototype, to provide outsiders (e.g. at conferences) an insight into potential sound expressions as they arise in interplay with the walker's movements in a respective situation. The animations were created using real audio recordings files as sound tracks for an animated figure (Appendix C.3.1). Even though the creation of this representation is time consuming, it gives a first approximation

[1]Examples include Figure C.1, Figure 5.5 and Figure 6.1

to the experience.

In fact, the designer's unmediated felt experience of interactive sound turned out to be essential step of the design process, that is a first-person perspective (Section 5.7.5). We have described this perspective as follows: "a first-person perspective places the user's lived experience at the core of the design process—the lived experience of moving and being moved become the main unifying activity during the design process." (Kristina Höök et al., 2018, p.3). Here, the own bodily experience becomes the dialogue partner who as Donald Schön puts it "talks back" Schon (1984, p.79). In order to enable this perspective and integrate it in the design process, the use of the visual programming tool Pure Data which allows the dynamic modification of parameters has proven to be very helpful.

Lastly, one challenge of doing research-through-design is to describe the parallel running interwoven strands of developing a prototype in an analytical manner and to bring the cyclical development into a linear form of written text.

7.3 Contribution and Implications

The possibility to augment physical activities with interactive sound opens up a wealth of possibilities to design for everyday activities and experiences. This thesis presented an overall design approach *GangKlang* as an alternative to outcome-oriented approaches, by focusing on the processual and unfolding nature of daily activities. Despite its exploratory nature, this thesis contributes to the advance of research in sonic interaction and experience design for everyday life activities.

GangKlang comprises two contributions that complement existing design approaches: a bottom-up model of everyday walking experiences, *Walking Phrases*, and a translation framework (*GangKlang-Translations*) to design sonic expressions on the basis of the activity structure and to strengthen the walker's experience of the unfolding process.

The activity-approach to experiences used in this thesis has proven its worth in modeling for everyday life walking. The findings of the walking study (Chapter 5) show that focusing on the walker's movement process is suitable for uncovering basic structures through which walking processes and related experiences unfold. The resulting model *Walking Phrases* provides a means to capture the individual walking context without having to predefine a setting or locative points of interest. This approach is promising in order to adapt system feedback to the individual context, regardless of the objective of the activity. *Walking Phrases* thereby contributes to the field of mobile interaction design specifically and more generally to the advance of knowledge related to design for everyday life activities and experiences. While the focus in this thesis has been on walking movement and sonic feedback, this form of adaptation can also be used for other input and feedback modalities. For instance, desktop applications may analyze the user's rhythm of keyboard or mouse input in order to adapt visual feedback according to cognitive resources.

The translation framework draws on the evolving activity structure to design sonic expressions and consists of two integrated pillars: translation constructs and *Sonic Seduction*. The translation constructs enable the overall organization of the individual sound events in the sonic expression. *Sonic Seduction* is a strategy to influence the walker's experience with the aim to foreground the walking process. Here, the stabilization and destabilization of the walker's movements is transformed into sonic figures that emerge and dissolve, which in turn shall draw the walker's attention to the walking process itself. The framework complements experience-oriented approaches in the field of sonic interaction design that focus on interaction with artifacts (Franinović, 2013), single movements (Caramiaux et al., 2015) or locative aspects (Hazzard, 2016). While these approaches use body movement as a means to an end, it becomes the central aspect in the translation schema of *GangKlang*.

The designed prototypes demonstrate the use of the translation constructs to design sonic expressions for different walking settings, e.g. walking in a in a park, in a location-based mobile game or in daily life. This approach provides a solution to reflect the multidimensionality (Effenberg et al., 2005), that is the different parallel developing sub-processes of daily activities in a sonic expression. The findings from the everyday study confirm that *Sonic Seduction* can be used to facilitate the experience of the walking process in daily life. Moreover, the results suggest that *Sonic Seduction* can be used as an additional structuring condition for walking.

Altogether, the findings in this thesis confirm that interactive sound can be designed to strengthen the walker's experience of the process itself and thereby improve walking experiences in daily life. The findings add to a growing corpus of research exploring the design and use of interactive sound and specifically extends to understanding how they can be designed to enhance the experience of everyday activities.

Results gained in this thesis have been published in the following publications:

Gait Biometrics in Interaction Design: A Work in Progress Report
Hajinejad N, Bogutzky S, Grüter B (2012) In: Reiterer H, Deussen O (eds) Mensch & Computer 2012 – Workshopband: interaktiv informiert – allgegenwärtig und allumfassend!?. Oldenbourg Verlag, München, pp 141–146.

GangKlang: Designing Walking Experiences
Hajinejad N, Grüter B, Bogutzky S, Vatterrott H-R (2013) In: Proceedings of the 8th Audio Mostly Conference. ACM, New York, NY, USA, pp 15:1–15:6

Walking Phrases: modeling the walking process with respect to contextual conditions

Hajinejad N, Grüter B, Bogutzky S (2016) In: Mensch und Computer 2016 - Workshopband. de Gruyter Oldenbourg, Aachen

GangKlang: Facilitating a Movement-oriented Walking Experience Through Sonic Interaction

Hajinejad N, Grüter B, Roque L, Bogutzky S (2016) In: Proceedings of the Audio Mostly 2016. ACM, New York, NY, USA, pp 202–208

Prototyping Sonic Interaction for Walking

Hajinejad N, Grüter B, Roque L (2017) In: Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services. ACM, New York, NY, USA, pp 98:1–98:8

Walking Phrases: Modeling the Walker's Context for Sonic Interaction Design

Hajinejad N, Roque L, Grüter B (2017) In: Proceedings of the 12th International Audio Mostly Conference on Augmented and Participatory Sound and Music Experiences - AM '17. ACM Press, London, United Kingdom, pp 1–8

Embracing First-Person Perspectives in Soma-Based Design

Höök K, Caramiaux B, Erkut C, et al. (2018) Informatics 5:8. https://doi.org/10.3390/informatics5010008

Scaffolding walking experiences through interactive sound design

Hajinejad N (accepted, to appear) In: Piga B.EA, Daniel S, Thibaud J-P (eds) EXPERIENTIAL WALKS FOR URBAN DESIGN. Revealing, Representing, and Activating the Sensory Environment.

7.4 Further Research

The research of this thesis has an exploratory character and offers a number of starting points for further research.

Modelling core mechanics

This work has focused on the walking activity to develop the process-oriented design approach. The core mechanics of walking activity can be well defined by the gait cycle. However, identifying the core mechanics of other daily activities such as cooking or washing is far more challenging. A fruitful topic of further research might be the development of methods for identifying core mechanics which structure a physical activity. Being able to identify core mechanics dynamically would be of particular relevance for the domain on everyday activities. For instance Hansen and Morrison Hansen and Morrison (2014) suggest repetition and frequency as basic modalities to parse semantic movement units.

Notation system for design of interactive sound

As already mentioned, the notation of interactive sounds poses a particular challenge and has not been systematically investigated in this thesis. This is an interesting and useful area for future research. Traditional notation systems are particularly concerned with how sounds are organized in time. A notation system for interactive sound should also represent the dependence of the sounds on the user's body movement and the dynamics of the overall activity.

Dynamic sonic figures as influencing forces

The constructs of the translation framework provide the possibility to design for a multitude of dynamically generated sonic figures. Depending on the particular set of sonic material that is handled with these constructs, very different sonic expressions will be created. Further research could focus more closely on the relation between the sonic figures that are enabled and the walking experiences that are supported, i.e the affordances of the dynamic sonic figures. The sound figures that have been presented above were designed with the aim to strengthen the experience of the walking process. What other aspects of walking could be supported by design of other sonic figures? Exploring this question would connect research on musical gestures (GodøY and Leman, 2010) to design for daily activities and experiences.

Sustainable Change and Metamorphosis

Further studies need to be carried out in order to validate the effect of unfolding sonic figures on the walker's experiences. In particular, a study to assess the long-term effects of this strategy would be worthwhile. Are there any lasting effects of using applications that enable interactive sounds and can they contribute to a fundamental change of opinion on daily activities? This strategy is closely related to research in musical gestures(ibid.) and the concept of musical affordances as presented by Rolf Inge Godoy (ibid.).

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Appendices

A | Documents Study A

Study A has been presented in Section 4.3. It was carried out with the first prototype (Study A) and five participants in March 2014.

A.1 Empirical Data

In this study, process data was collected using a mobile application on each participant's smartphone. At application start, process data was stored in a CSV format (.csv) with corresponding timestamps. The process data includes GPS coordinates (timestamp, latitude, longitude, attitude) and motion data (timestamp, acceleration(XYZ), gravity(XYZ), rotation(XYZ) and attitude(YawRollPitch)).

The process data of all five participants can be found on the following link: https://gangklang.gangs-of-bremen.de/prototyp1/#studyA

The table below includes a list of annotations created in the process analysis for the activity of participant 5 (named Lara). The Chronoviz file created for the process analysis can be found on the following link: http://gangklang.gangs-of-bremen.de/wp-content/uploads/2020/01/p5_chronoviz.annotation.zip

Von (min)	Bis (min)	Ereignis	Richtung / Ort	Sound	Sozialer Kontext	Gehverhalten	Interpretation
1:20	1:53	L. passiert zum ersten mal eine Klangraumgrenze. L. tritt von der Klanglandschaft Wald in die Klanglandschaft Kirche		Der Ambient Wald verstummt innerhalb von 3 sek. , es herrscht 5 sek stille, anschließend wird innerhalb von 5 sek der Kirchen-Ambient eingeblendet (13sek)		Schrittlänge nimmt ab	Deutet an, dass sie aufmerksamer und vorsichtiger wird
1:53			Wende			Schrittlänge wird wieder größer.	Sie hat entscheiden umzudrehen.
2:08	2:18	SweetSpot ertönt 2:08.7		Ambient verstummt innerhalb von 3 sek.Glissando-Effekt auf einem Chimes 6 sek		bleibt stehen, dreht sich um die eigene Achse	hat die Besonderheit des Ortes bemerkt und schaut sich um
2:18	5:05:00		über den Spielplatz zum Tümpel	Ambientwechsel beim Spielplatz(3:25) von Wald zu Tümpel, Ambientwechsel nach dem Spielplatz (4:25) von Tümpel zu Stadt		...	...
5:05	5:27	Übergang Stadt-Tümpel		Ambientwechsel von Stadt zu Tümpel		verlängert die Schritte (ab 5:10)	?
5:27	6:36		weiter zur Kirche		...	...	...
6:36	7:07	schließt sich mit Mitspielern zusammen	läuft zu Mitspieler-Gruppe bei der Kirche		schließt sich mit Mitspielern zusammen	bleibt stehen	sucht Kontakt, möchte mit den Mitspielern laufen
7:55	8:54		in der nähe eines Gebäudes		Gemeinsames Erkunden am Gebäude	bleibt stehen	gemeinsames erkunden in der Gruppe
9:15	9:26	ein zuvor unbedeutender Ort wird wichtig			diese stelle ist zuvor für P4 und P1 von Interesse gewesen, SweetSpot von P1 wurde hier gesetzt	kleine schritte, läuft eine schleife	der Ort gewinnt an Bedeutung weil er für P1 bedeutend ist
9:26	11:53		zum Spielplatz				
11:53	14:20	Spielplatz	halten sich beim Spielplatz auf			stehen, schleifen	
14:20	15:20		zur Kirche				
15:20							
17:40		Richtungswechsel			trennt sich von Mitspielern	geht gleichmäßig	Zielsicher, möchte zu dem Ort wo sie den SweetSpot gehört hat
18:10	18:30	sucht SweetSpot			wenige Meter vom SweetSpot entfernt	bleibt stehen , dreht kleine runden	
18:55		passiert Klangraumgrenze				kleine Schritte	
20:00		markiert SweetSpot					
20:22		beendet das Spiel					

Table A.1: Table including annotations to reconstruct the play activity of Participant 5.

Figure A.1: A map of the play area and pictures of the park.

A.2 Declaration of Consent

Einverständniserklärung zu den Workshops „Mobile Spiele“ des Forschungsprojektes Flow-Maschinen in Zusammenarbeit mit der DIAKO Bremen am 12.12.2013, 06.03.2014, und 20.03.2014

Gangdaten und Interviews

Im Rahmen der Workshops werden Gangdaten und Interviews aufgezeichnet. Diese dienen der Dokumentation und der wissenschaftlichen Auswertung des Projektes und werden Dritten nicht zugänglich gemacht. Darüber hinaus können zur Veranschaulichung auf wissenschaftlichen Konferenzen die ausgewerteten Daten und Interviewergebnisse verwendet werden. Persönliche Daten (wie der Name) werden jedoch nicht veröffentlicht.

Fotos und Videos

Mit ihrer Zustimmung werden zusätzlich Foto- und Videoaufnahmen erstellt und in die wissenschaftliche Auswertung miteinbezogen. Auch hier werden persönliche Daten geschützt.

Bilder und Videos, die während der Workshops gemacht wurden, werden wie folgt freigegeben:

☐ Ja ☐ Nein Hiermit stimme ich der Verwendung von Fotos und Videos zu ausschließlich wissenschaftlichen Zwecken (Konferenzen, Tagungen, etc.) zu.

☐ Ja ☐ Nein Hiermit stimme ich der Präsentation von Fotos und Videos im Internet (z. B. auf der Webseite www.mobilegamelab.de) zu.

Hiermit stimme ich zu, dass mein Kind an den Workshops teilnimmt.

Datum, Unterschrift

B | Documents Study B

Study B has been presented in Chapter 6. It was carried out with the third prototype and 12 participants in June 2015. In this study, interview and process data was collected.

B.1 Walking Sessions

Person	Alter	Datum	Dauer (s)	Dauer (min)	Schritte	Mittlere Schritt-frequenz	Audio-Feedback	Gangdaten nutzbar	IS Detection
Anne, w	27	Di., 02. Juni 2015 14:16:43	773	0:13	1336	104	FALSCH	WAHR	FALSCH
		Di., 02. Juni 2015 14:41:27	783	0:13	1338	103	FALSCH	WAHR	FALSCH
		Do., 04. Juni 2015 13:18:47	744	0:12	1330	107	FALSCH	WAHR	FALSCH
		Do., 04. Juni 2015 13:43:29	798	0:13	1360	102	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 15:05:20	761	0:13	1340	106	WAHR	WAHR	WAHR
		Di., 09. Juni 2015 15:25:56	755	0:13	1320	105	WAHR	WAHR	FALSCH
		Fr., 12. Juni 2015 18:44:15	848	0:14	1286	91	WAHR	WAHR	WAHR
		Fr., 12. Juni 2015 19:23:12	750	0:13	1314	105	WAHR	WAHR	WAHR
Bonnie, w	30	Di., 09. Juni 2015 17:44:37	948	0:16	1648	104	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 18:04:55	911	0:15	1632	107	FALSCH	WAHR	WAHR
		Mi., 10. Juni 2015 9:23:41	905	0:15	1708	113	FALSCH	WAHR	WAHR
		Mi., 10. Juni 2015 9:39:55	945	0:16	1758	112	FALSCH	WAHR	WAHR
		Di., 16. Juni 2015 16:36:46	990	0:17	1510	92	WAHR	WAHR	WAHR
		Di., 16. Juni 2015 16:54:50	930	0:16	1480	95	WAHR	WAHR	WAHR
		Mi., 17. Juni 2015 8:38:26	949	0:16	1522	96	WAHR	WAHR	WAHR
		Mi., 17. Juni 2015 8:54:56	992	0:17	1640	99	WAHR	WAHR	WAHR
Dan, m	27	Di., 02. Juni 2015 17:45:50	919	0:15	1740	114	FALSCH	WAHR	FALSCH
		Di., 02. Juni 2015 18:33:15	956	0:16	1790	112	FALSCH	WAHR	FALSCH
		Do., 04. Juni 2015 17:08:09	890	0:15	1662	112	FALSCH	WAHR	FALSCH
		Do., 04. Juni 2015 17:48:50	905	0:15	1708	113	FALSCH	WAHR	FALSCH
		Mi., 10. Juni 2015 18:54:04	965	0:16	1782	111	WAHR	WAHR	WAHR
		Mi., 10. Juni 2015 19:58:48	963	0:16	1660	103	WAHR	WAHR	WAHR
		Do., 11. Juni 2015 18:42:02	865	0:14	1584	110	WAHR	WAHR	WAHR
		Do., 11. Juni 2015 19:29:47	932	0:16	1730	111	WAHR	WAHR	FALSCH
Heidi, w	26	Mo., 01. Juni 2015 12:08:11	1069	0:18	1960	110	FALSCH	WAHR	WAHR
		Mo., 01. Juni 2015 12:51:34	1052	0:18	1882	107	FALSCH	WAHR	FALSCH
		Fr., 05. Juni 2015 15:01:21	1009	0:17	1880	112	FALSCH	WAHR	WAHR
		Fr., 05. Juni 2015 15:33:16	1081	0:18	1886	105	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 12:34:27	1106	0:18	1920	104	WAHR	WAHR	FALSCH
		Di., 09. Juni 2015 13:05:48	1014	0:17	1892	112	WAHR	WAHR	FALSCH
		Mo., 15. Juni 2015 9:32:58	1059	0:18	1902	108	WAHR	WAHR	WAHR
		Mo., 15. Juni 2015 10:02:56	993	0:17	1850	112	WAHR	WAHR	WAHR
Kyra, w	30	Mi., 03. Juni 2015 8:47:48	1125	0:19	1714	91	FALSCH	FALSCH	FALSCH
		Mi., 03. Juni 2015 23:04:41	1326	0:22	1778	80	FALSCH	WAHR	WAHR
		Do., 04. Juni 2015 8:26:11	1284	0:21	2028	95	FALSCH	WAHR	WAHR
		Do., 04. Juni 2015 23:04:35	996	0:17	1834	110	FALSCH	WAHR	FALSCH
		Mo., 08. Juni 2015 8:23:32	1200	0:20	2014	101	FALSCH	WAHR	FALSCH
		Di., 09. Juni 2015 21:45:07	1326	0:22	2060	93	FALSCH	WAHR	FALSCH
		Di., 09. Juni 2015 22:23:59	1349	0:22	2054	91	FALSCH	WAHR	FALSCH
		Mo., 15. Juni 2015 8:04:21	1328	0:22	1808	82	WAHR	FALSCH	FALSCH
		Mo., 15. Juni 2015 23:05:38	1223	0:20	882	43	WAHR	FALSCH	FALSCH
		Di., 16. Juni 2015 8:10:27	1207	0:20	1752	87	WAHR	FALSCH	FALSCH
		Di., 16. Juni 2015 22:14:17	1120	0:19	1726	92	WAHR	WAHR	WAHR

Table B.1: Information on participants and their walking sessions.

Person	Alter	Datum	Dauer (s)	Dauer (min)	Schritte	Mittlere Schritt-frequenz	Audio-Feedback	Gangdaten nutzbar	IS Detection
Lucy, w	31	Di., 02. Juni 2015 11:20:15	826	0:14	1516	110	FALSCH	WAHR	FALSCH
		Di., 02. Juni 2015 12:20:37	1016	0:17	1604	95	FALSCH	FALSCH	FALSCH
		Di., 09. Juni 2015 8:35:50	830	0:14	1596	115	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 15:21:51	945	0:16	1650	105	FALSCH	WAHR	WAHR
		Mi., 10. Juni 2015 10:40:52	838	0:14	1574	113	WAHR	WAHR	WAHR
		Mi., 10. Juni 2015 16:45:12	1059	0:18	1712	97	WAHR	WAHR	WAHR
		Di., 16. Juni 2015 8:35:52	901	0:15	1594	106	WAHR	WAHR	FALSCH
		Di., 16. Juni 2015 14:58:55	995	0:17	1578	95	WAHR	WAHR	FALSCH
Mia, w	25	Sa., 06. Juni 2015 15:18:14	783	0:13	1314	101	FALSCH	WAHR	WAHR
		Sa., 06. Juni 2015 15:54:35	871	0:15	1440	99	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 17:09:40	847	0:14	1408	100	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 19:10:17	884	0:15	1438	98	FALSCH	WAHR	WAHR
		Sa., 13. Juni 2015 20:15:18	809	0:13	1150	85	WAHR	FALSCH	FALSCH
		Sa., 13. Juni 2015 20:53:10	842	0:14	1092	78	WAHR	FALSCH	FALSCH
		Mo., 15. Juni 2015 10:30:05	802	0:13	1082	81	WAHR	FALSCH	FALSCH
		Mo., 15. Juni 2015 12:02:12	849	0:14	1410	100	WAHR	WAHR	WAHR
Miles, m	27	Mi., 10. Juni 2015 20:22:03	974	0:16	1768	109	FALSCH	WAHR	FALSCH
		Mi., 10. Juni 2015 21:07:36	999	0:17	1620	97	FALSCH	WAHR	WAHR
		Do., 11. Juni 2015 20:50:48	1297	0:22	1758	81	FALSCH	FALSCH	FALSCH
		Do., 11. Juni 2015 21:38:19	1065	0:18	1776	100	FALSCH	WAHR	WAHR
		Mi., 17. Juni 2015 17:56:34	885	0:15	1458	99	WAHR	WAHR	WAHR
		Mi., 17. Juni 2015 18:12:16	867	0:14	1452	100	WAHR	WAHR	FALSCH
		Mi., 17. Juni 2015 18:27:27	968	0:16	1628	101	WAHR	WAHR	FALSCH
		Mi., 17. Juni 2015 18:44:33	994	0:17	1656	100	WAHR	WAHR	WAHR
Sue, w	28	Mi., 03. Juni 2015 17:14:29	866	0:14	1436	99	FALSCH	WAHR	WAHR
		Mi., 03. Juni 2015 17:30:44	879	0:15	1448	99	FALSCH	WAHR	FALSCH
		Mo., 15. Juni 2015 17:25:37	871	0:15	1460	101	FALSCH	WAHR	WAHR
		Mo., 15. Juni 2015 17:51:57	798	0:13	1320	99	FALSCH	WAHR	WAHR
		Mi., 17. Juni 2015 15:30:30	934	0:16	1422	91	WAHR	WAHR	WAHR
		Mi., 17. Juni 2015 16:05:45	862	0:14	1438	100	WAHR	WAHR	FALSCH
		Do., 18. Juni 2015 10:19:23	819	0:14	1402	103	WAHR	WAHR	WAHR
		Do., 18. Juni 2015 10:38:25	903	0:15	1448	96	WAHR	WAHR	WAHR

Table B.2: Information on participants and their walking sessions.

Person	Alter	Datum	Dauer (s)	Dauer (min)	Schritte	Mittlere Schritt-frequenz	Audio-Feedback	Gangdaten nutzbar	IS Detection
Sue, w	28	Mi., 03. Juni 2015 17:14:29	866	0:14	1436	99	FALSCH	WAHR	WAHR
		Mi., 03. Juni 2015 17:30:44	879	0:15	1448	99	FALSCH	WAHR	FALSCH
		Mo., 15. Juni 2015 17:25:37	871	0:15	1460	101	FALSCH	WAHR	WAHR
		Mo., 15. Juni 2015 17:51:57	798	0:13	1320	99	FALSCH	WAHR	WAHR
		Mi., 17. Juni 2015 15:30:30	934	0:16	1422	91	WAHR	WAHR	WAHR
		Mi., 17. Juni 2015 16:05:45	862	0:14	1438	100	WAHR	WAHR	FALSCH
		Do., 18. Juni 2015 10:19:23	819	0:14	1402	103	WAHR	WAHR	WAHR
		Do., 18. Juni 2015 10:38:25	903	0:15	1448	96	WAHR	WAHR	WAHR
Tobi, m	36	Di., 09. Juni 2015 10:58:53	1708	0:28	3046	107	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 18:26:00	1610	0:27	2756	103	FALSCH	WAHR	WAHR
		Fr., 12. Juni 2015 11:02:51	1706	0:28	4322	152	WAHR	FALSCH	FALSCH
		Fr., 12. Juni 2015 16:46:57	2077	0:35	2800	81	WAHR	FALSCH	FALSCH
Tom, m	35	Di., 02. Juni 2015 20:50:43	1488	0:25	2674	108	FALSCH	WAHR	FALSCH
		Mo., 08. Juni 2015 19:26:53	1658	0:28	2808	102	FALSCH	WAHR	WAHR
		Di., 09. Juni 2015 21:48:55	1706	0:28	1732	61	FALSCH	FALSCH	FALSCH
		Mi., 10. Juni 2015 23:22:41	1641	0:27	2686	98	FALSCH	WAHR	WAHR
		Mo., 15. Juni 2015 23:04:24	1627	0:27	2660	98	WAHR	FALSCH	FALSCH
		Di., 16. Juni 2015 9:12:38	1408	0:23	2592	110	WAHR	WAHR	FALSCH
Vera, w	35	Mo., 01. Juni 2015 19:05:13	1482	0:25	2652	107	FALSCH	WAHR	WAHR
		Mo., 01. Juni 2015 22:16:36	1621	0:27	2814	104	FALSCH	WAHR	WAHR
		So., 07. Juni 2015 22:07:02	1217	0:20	2290	113	FALSCH	WAHR	WAHR
		So., 07. Juni 2015 22:28:39	1244	0:21	2882	139	FALSCH	WAHR	WAHR
		Mo., 08. Juni 2015 18:57:29	1431	0:24	2560	107	WAHR	WAHR	FALSCH
		Mo., 08. Juni 2015 21:43:27	1606	0:27	2728	102	WAHR	WAHR	WAHR
		Mo., 15. Juni 2015 19:06:56	1159	0:19	2046	106	WAHR	WAHR	WAHR
		Mo., 15. Juni 2015 22:22:21	1223	0:20	2202	108	WAHR	WAHR	WAHR

Table B.3: Information on participants and their walking sessions.

B.2 Interview Procedure

Procedure and Questions of Interview I

- Explaining the iPhone and usage of the App.
- Defining an individual route of about 15 minutes walking duration.

Procedure and Questions of Interview II

- How's this week been for you?
- Did you notice anything while walking?

Procedure and Questions of Interview III

- How was using the app this week?
- How would you describe what you have heard?
- Do you think what you heard was influenced by you?
- Was walking different from the week before?
- Would you use the application in future?

The table below includes transcribed statements and notes used in the analysis of the subjective reports and shows their organization into themes.

PARTICIPANT	TIME	ATTENTION	INTERACTIVITY	WALKING MOVEMENT	SONIC EXPRESSION	RHYTHMIC /MELODIC
ANNE		• „mehr auf die eigene Bewegung“ - den einzelnen Schritt - „geachtet“, damit hat sich das Gehen bewusster angefühlt. • „Gehen hat sich bewusster angefühlt“ und dadurch „psychisch anstrengender wahrgenommen“ • „gedanklich irgendwo und hab gar nicht mehr auf das Gehen gedacht und das war halt [mit Feedback] nicht so“ • „also aus diesem Gedankenprozess bin ich immer wieder herausgeholt worden“	• Zusammenhang zwischen dem Aufsetzten ihrer Füße und dem „Klopfen“ festgestellt • „zwischendurch setzt sie ja auch aus, das ist von daher komisch weil man erwartet dass es wieder losgeht“	• „mehr auf die eigene Bewegung“ - den einzelnen Schritt - „geachtet“, • „Gehen hat sich bewusster angefühlt“ • „psychisch anstrengender wahrgenommen“	• „Nach kurzer Zeit hat mich diese ganze Musik ziemlich genervt muss ich sagen“	• „es gab diesen einen Ton […] dieses sphärische“ • „so ein gleichmäßiges Klopfen […] und dann setzt so ein Hinterundgeräusch ein […] so lange Töne“
BONNIE	• „viel langsamer gefühlt“	• nicht wie sonst die Kirchenglocken wahrgenommen, obwohl GK nicht laut; • kann sich diese Art der Musik gut zum Spazierengehen vorstellen: “dass man sich einfach mal auf sich konzentriert“	• Nicht erkannt: „hätte ich das merken müssen?“	• „ich habe mich selber langsamer gefühlt tatsächlich ja mit der Musik“ • „vielleicht weil ich entspannt war, also ich fand es angenehm mit der Musik“	• „ich habe mich selber langsamer gefühlt tatsächlich ja mit der Musik“ • „vielleicht weil ich entspannt war, also ich fand es angenehm mit der Musik“	• „Immer dieser Piep, also dieser eine Ton, immer wiederholt und dann so eine kleine Melodie“
DAN	• „anders vorgekommen in dem sinne vielleicht, dass es irgendwie schneller vorbeigegange n ist, durch die Musik vielleicht auch, also ich habe das Gefühl gehabt, dass es irgendwie schneller ging obwohl ich die gleiche Anzahl an Minuten gebraucht habe effektiv, aber die Zeit ging irgendwie schneller rum gefühlt“	• „also vorher hatte ich mir ja Gedanken gemacht als ich ohne Musik gegangen bin“ • „einfach gegangen, die Melodie dazu gehört und an nix großartig gedacht“ • „ich hatte mich mehr auf die Musik konzentriert und nicht über viele andere Sachen nachgedacht“ • “ohne Musik war ich ein bisschen gedankenversunkener“ • “mit der Musik Entspannung so ein bisschen nicht viel nachdenken, als die Pausen waren dann hat man mehr nachgedacht“		• „ich bin jetzt nicht schneller oder nach dem Rhythmus der Musik gegangen“ • „bin so meinen Rhythmus eigentlich weitergegangen“	• „so chilling Backgroundmusik, sowas im Hintergrund“	• „einzelne Töne zu Anfang und dann wurde das nacheinander so ein bisschen fließender, dass es quasi so eine Melodie wurde“
HEIDI		• „ruhiger“ • „mehr in mich gekehrt“ • „ruhiger war und mich mehr so darauf einlassen konnte auf diesen ganzen Gehvorgang“ • „[die Klänge] waren mehr im Hintergrund, manchmal bin ich aus meiner Gedankenwelt aufgewacht …. und habe festgestellt ok jetzt ist grad gar Kein klang mehr“	• „ich hatte schon das Gefühl, als ich ein bisschen länger gegangen war und so drin war, sozusagen da gab’s diesen einen ganz ruhigen Unterton Beat war das irgendwie…da hatte ich schon das Gefühl das der irgendwie … entweder habe ich mich an den oder der sich an mich, irgendwie gab’s da so’n Zusammenhang“	• „mein Gang mehr abgeschweift ist“	„ sie würden irgendwann langweilig werden, müsste man variieren“	• „2-3 Grundmuster die sich abgewechselt haben, mit Pausen dazwischen“
KYRA	• „viel energetischer unterwegs“ • „ging echt flotter“ • „leichtfüßiger, sonst mega die Zeit , Entfernungen im Gefühl“	• „aufmerksames Horchen und dabei einfach den Weg gehen“ • „weniger Auseinandersetzungen gehabt im kopf“	• „als würde ich auf Stöckelschuhen laufen“	• „als hätte man gerade Kaffee getrunken, bin ich flott gegangen“ • „es war leicht-füßiger“		• „ein kleiner Aufbau an Klängen, dann Grundrhythmus den meine Schritte vorgegeben haben“ • „zwischendurch sehr angenehme Melodien, die mich beschwingt haben….schade dass die abgebrochen sind“ • „Wellenmelodien“

Table B.4: Transcribed statements and notes used in the analysis of the subjective reports.

PARTICIPANT	TIME	ATTENTION	INTERACTIVITY	WALKING MOVEMENT	SONIC EXPRESSION	RHYTHMIC /MELODIC
LUCY		• „ich bin auf jedenfalls mehr bei mir und nicht so in dieser Umgebung oder einfach nicht so abgelenkt von dem was so um mich rum passiert“ • „dass ich dadurch dass ich irgendwie was höre was sich an diesen, an meine Bewegung auf irgendeine art ja schon anpasst, dass sich also dass das schon mir irgendwie das Gefühl gibt mehr bei mir zu sein… und meine Aufmerksamkeit irgendwie darauf lenkt “ • „dem Prozess mehr Aufmerksamkeit geschenkt“ • anderes Setting: „wird die Strecke mehr zu einer Einheit“	• „im Rhythmus meines Gehens ist“ • „ was höre was sich an diesen, an meine Bewegung auf irgendeine art ja schon anpasst“ • „es reagiert ja schon da daruf ob du jetzt stehst oder gehst und auf die Geschwindigkeit“		• „irgendwas wie eine Beat“ • „durch diese Wiederholung so abgenervt“ • „ich hab mich gestört davon gefühlt dass es aussetzt und dann wieder anfängt“ • „diese Art der Musik oder des Klanges hat etwas meditatives“	• „klimperiges“
MIA			• „ich habe die ganze zeit versucht zu hören ob es sich den schritten anpasst, aber ich glaube nicht“ • „manchmal hatte man das Gefühl die klänge passen auf die Schritte, aber ich glaube das ist eher Zufall gewesen“ • „manchmal hatte man das Gefühl die Klänge passen auf die schritte, aber ich glaube das ist eher Zufall gewesen“	• „ich glaub schon, dass man sich den Klängen angepasst hat“	• „mit der Musik war es wirklich anders, die Musik hat mich müde gemacht“ • „ich fand es nicht so spannend““	
MILES		• „sobald die Musik anwarb, war ich weg vom Kopf her“ • „gefühlt schneller in Trance- oder wie man das nenn soll- Gedankenverloren war mit Musik“ • erst bei den Stillintervallen „zurück in die Gegenwart geholt wurde“	• „gefühlt doch schon so rhythmisch waren dass sie zum Gangbild passten“ • „Xylophon in Schrittvariante“		• „Musik“	• „beginnt mit leichten Klängen“ • „Xylophon in Schrittvariante“ • „daneben tiefere Töne die sich zu einer Melodie vervollständigen“
SUE		• „interessant weil mich das irgendwie bewusster hat laufen lassen, nicht dass es das bewertet hat also es gab dann ein nachdenken über das Laufen tatsächlich, wie ich laufe“ • „also ich war trotzdem mit meinen Gedanken beschäftigt“	• „vom Rhythmus her auf meinen Schritt abgestimmt“ • „in dem Moment wo ich das Gefühl hatte es ist mein Begleiter weil es auf mich reagiert hat hat es mir auch so ein bisschen, vielleicht Kraft so, oder sowas gegeben, das war ein schönes Gefühl“		• „Schön entspannte Musik, also es hat mich so beruhigt, nicht dass ich aufgebracht war aber es hat mir eine Ruhe gegeben beim laufen, so dass ich auch ein bisschen ruhiger nachdenken konnte“ • „weil der Grundton ein sehr beruhigender ist, es waren ja sehr angenehme Klänge, sehr ruhige klänge, dass das meine Gedanken eher positiv beeinflusst hat,…das mich ein Thema nicht so aufgewühlt hat, so ein bisschen harmonischer irgendwie in meinem kopf zuging vom Gefühl her“	• „diese Melodie die sich wiederholt hat“

Table B.5: Transcribed statements and notes used in the analysis of the subjective reports.

PARTICIPANT	TIME	ATTENTION	INTERACTIVITY	WALKING MOVEMENT	SONIC EXPRESSION	RHYTHMIC /MELODIC
TOM	trotz beruhigender Klänge, gefühlt schneller gelaufen	• „mehr so ein abgeschirmt sein“ • „es ist weg das außen, es ist jetzt wirklich nur noch und das laufen und ebenen der Klang sozusagen und nicht was für Geräusche, wo bellt ein Hund“	• „einer der Geräusche war mein Schritt, die Geschwindigkeit meiner Beinbewegung“ • „das Gefühl von Beeinflussbarkeit ja aber auch nicht“ • „es ist nicht völlig abhängig von dem was ich mache, sondern es passiert auch ohne das ich was also bewusst tue“	• „ich hatte das Gefühl dass ich die Strecke mit den klängen - obwohl es eher beruhigend ist - schneller gelaufen bin , die Zeit sagt aber dass es nicht so ist“	• "wenn die Musik eine beruhigende Wirkung hätte, was ich vermuten würde, auf Grund der Klänge sozusagen“ • „obwohl es eher beruhigend ist“	
VERA		• „unachtsamer“, • „spannendes nicht beachtet“ • „weniger rechts u. links geschaut“	• „wenn ich nicht mehr gelaufen bin wurde es still aber auch sonst Pausen“ • „sonst hatte ich nicht das Gefühl dass es was mit mir zu tun hat“	• „ich glaub tempomäßig gleich oder ähnlich“	• „Glockenklänge“ • „Dingdongs“ • „ich finde es total angenehm“ • „ich finde es ziemlich beruhigend irgendwie“	• „Und dann immer mal eine Ton und dann eine kleine Sequenz und dann die Sequenz rückwärts“ • „Hin und wieder ein Bassbeat“

Table B.6: Transcribed statements and notes used in the analysis of the subjective reports.

B.3 Objective Data Collection

In Section 6.5 an in-depth analysis was presented using the objective process data of participant 'Vera'. The process data used in this analysis can be found on the following link:

https://gangklang.gangs-of-bremen.de/prototyp3/#studyB

The process data was collected using the mobile application on the participant's iPhone. At application start, process data was stored in a CSV format (.csv) with corresponding timestamps. The process data includes: a) motion data (timestamp, acceleration(XYZ), gravity(XYZ), rotation(XYZ), attitude(YawRollPitch), b) tracked gait event data (timestamp, gait event type) and c) an audio file recording of the dynamically created sonic expression.

An example of using Observer for synchronizing data streams and to gain an overview on the walking process can be found on the following link: https://youtu.be/sujch4GDX5I

B.4 Information Leaflet

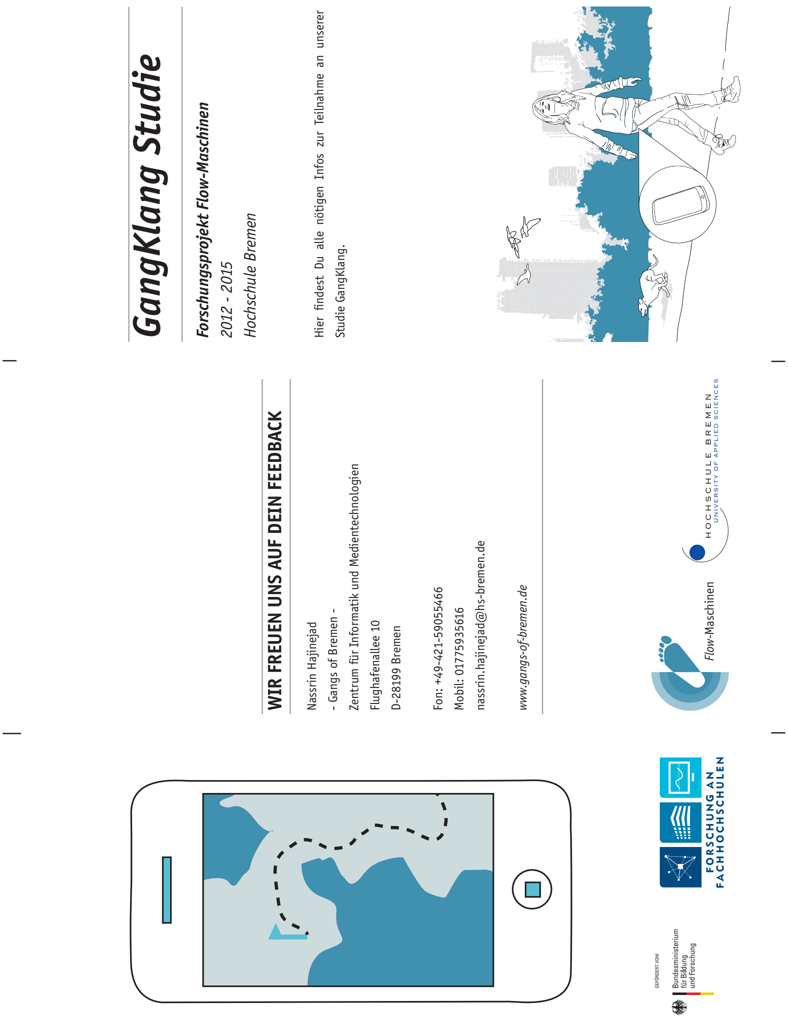
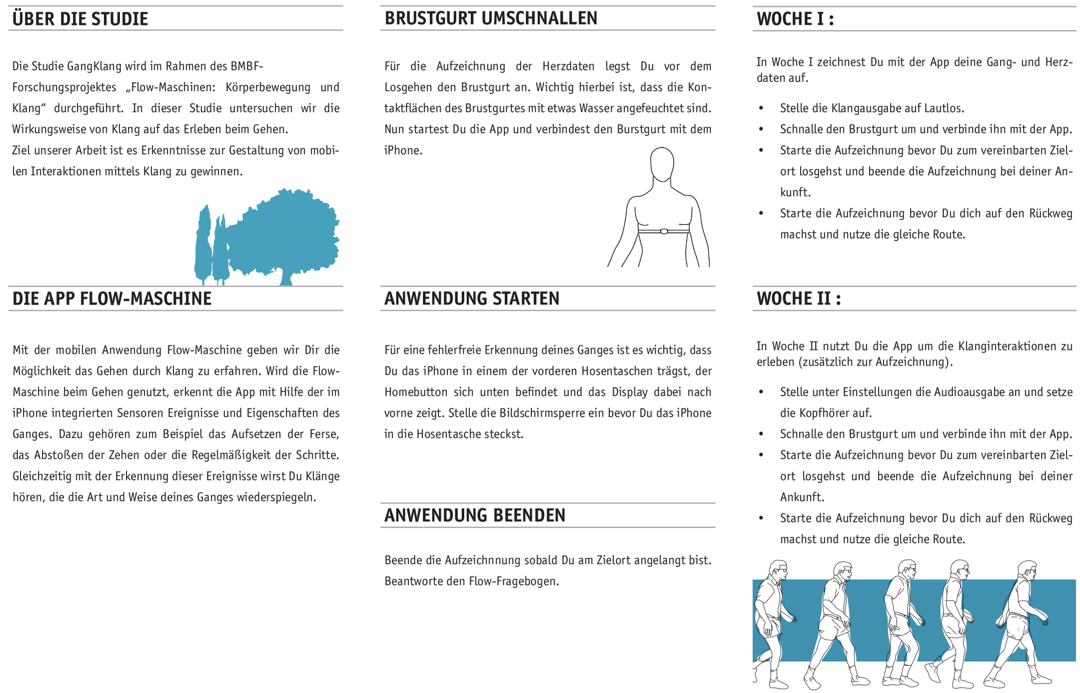


Figure B.1: Information leaflet passed on to study participants.



ÜBER DIE STUDIE

Die Studie GangKlang wird im Rahmen des BMBF-Forschungsprojektes „Flow-Maschinen: Körperbewegung und Klang“ durchgeführt. In dieser Studie untersuchen wir die Wirkungsweise von Klang auf das Erleben beim Gehen.
Ziel unserer Arbeit ist es Erkenntnisse zur Gestaltung von mobilen Interaktionen mittels Klang zu gewinnen.

DIE APP FLOW-MASCHINE

Mit der mobilen Anwendung Flow-Maschine geben wir Dir die Möglichkeit das Gehen durch Klang zu erfahren. Wird die Flow-Maschine beim Gehen genutzt, erkennt die App mit Hilfe der im iPhone integrierten Sensoren Ereignisse und Eigenschaften des Ganges. Dazu gehören zum Beispiel das Aufsetzen der Ferse, das Abstoßen der Zehen oder die Regelmäßigkeit der Schritte. Gleichzeitig mit der Erkennung dieser Ereignisse wirst Du Klänge hören, die die Art und Weise deines Ganges wiederspiegeln.

BRUSTGURT UMSCHNALLEN

Für die Aufzeichnung der Herzdaten legst Du vor dem Losgehen den Brustgurt an. Wichtig hierbei ist, dass die Kontaktflächen des Brustgurtes mit etwas Wasser angefeuchtet sind. Nun startest Du die App und verbindest den Burstgurt mit dem iPhone.

ANWENDUNG STARTEN

Für eine fehlerfreie Erkennung deines Ganges ist es wichtig, dass Du das iPhone in einem der vorderen Hosentaschen trägst, der Homebutton sich unten befindet und das Display dabei nach vorne zeigt. Stelle die Bildschirmsperre ein bevor Du das iPhone in die Hosentasche steckst.

ANWENDUNG BEENDEN

Beende die Aufzeichnnung sobald Du am Zielort angelangt bist.
Beantworte den Flow-Fragebogen.

WOCHE I :

In Woche I zeichnest Du mit der App deine Gang- und Herzdaten auf.

- Stelle die Klangausgabe auf Lautlos.
- Schnalle den Brustgurt um und verbinde ihn mit der App.
- Starte die Aufzeichnung bevor Du zum vereinbarten Zielort losgehst und beende die Aufzeichnung bei deiner Ankunft.
- Starte die Aufzeichnung bevor Du dich auf den Rückweg machst und nutze die gleiche Route.

WOCHE II :

In Woche II nutzt Du die App um die Klanginteraktionen zu erleben (zusätzlich zur Aufzeichnung).

- Stelle unter Einstellungen die Audioausgabe an und setze die Kopfhörer auf.
- Schnalle den Brustgurt um und verbinde ihn mit der App.
- Starte die Aufzeichnung bevor Du zum vereinbarten Zielort losgehst und beende die Aufzeichnung bei deiner Ankunft.
- Starte die Aufzeichnung bevor Du dich auf den Rückweg machst und nutze die gleiche Route.

Figure B.2: Information leaflet passed on to study participants.

B.5 Declaration of Consent

Einverständniserklärung

Ich ____________________________________

(Name, Vorname)

Geburtsdatum ____________________________________

Erkläre, dass ich die Teilnehmerinformation zur Studie

„ GangKlang“

und diese Einverständniserklärung zur Studienteilnahme erhalten habe.

- Ich wurde für mich ausreichend mündlich und/oder schriftlich über die wissenschaftliche Untersuchung informiert.
- Ich erkläre mich bereit, dass im Rahmen der Studie Daten über mich gesammelt und anonymisiert aufgezeichnet werden. Es wird gewährleistet, dass meine personenbezogenen Daten nicht an Dritte weitergegeben werden. Bei der Veröffentlichung in einer wissenschaftlichen Zeitung wird aus den Daten nicht hervorgehen, wer an dieser Untersuchung teilgenommen hat. Meine persönlichen Daten unterliegen dem Datenschutzgesetz.
- Ich weiß, dass ich jederzeit meine Einverständniserklärung, ohne Angabe von Gründen, widerrufen kann, ohne dass dies für mich nachteilige Folgen hat.
- Mit der vorstehend geschilderten Vorgehensweise bin ich einverstanden und bestätige dies mit meiner Unterschrift.

____

(Ort, Datum) (Unterschrift)

C | Sound Design Material

C.1 Prototype I

The audio files that have been used in design of Prototype I (Design Case Location-Based Audio Game) can be listened to using the following link:

https://gangklang.gangs-of-bremen.de/prototyp1

C.2 Prototype II

The audio files that have been used in design of Prototype II (Design case Inspector Tripton) can be listened to using the following link:

https://gangklang.gangs-of-bremen.de/prototyp2

C.3 Prototype III

The audio files that have been used in design of Prototype II (Design case Flow Machine) can be listened to using the following link:

https://gangklang.gangs-of-bremen.de/prototyp3

C.3.1 Animations

A number of animations have been created to illustrate the design of the dynamic sonic expression designed for this prototype. These video can be watched using the following links:

Prototype III - Walking, walking fast and stopping: https://www.youtube.com/watch?v=DJooGFZDkMU

Prototype III - Steady walking manner https://youtu.be/_Pto-MsU4So

Prototype III - Turning: https://youtu.be/RJKxljQJx-w

C.3.2 Storyboard

Figure C.1 illustrates a storyboard that was created to communicate the sound design ideas in the team.

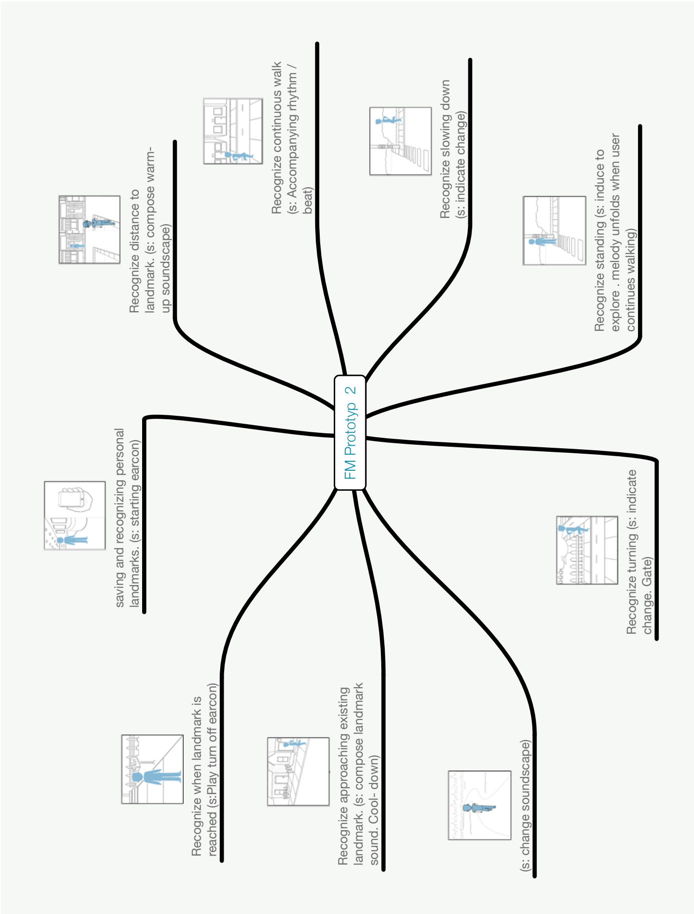


Figure C.1: A storyboard to communicate the design of sonic interaction mechanics for the mobile context.

D Implementation

D.1 Pure Data Patches

In Section 5.7.3, I have presented translation objects that I developed to translate walking information into sounds that organize in an overall sonic expression. In order to organize the playback of individual sounds in real-time, I have used the open source programming environment Pure Data (Pd) as a sound engine. In contrast to text-based programming languages, Pd is a graphical programming environment, where programs are called patches. To implement functions in a Pd patch, visual objects are used and connected by lines and messages. Complex Pd patches can be structured into sub-patches and external patches (abstractions) in order to provide a clear presentation. Abstractions are "reusable block of code saved as a separate Pd patch" [1]and can be used as objects in the main patch.

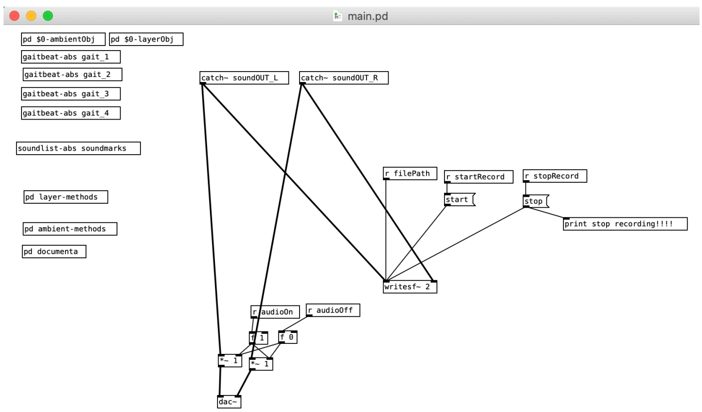


Figure D.1: Main canvas of the Pd patch GKmain.pd.

[1] http://write.flossmanuals.net/pure-data/glossary/

In the following I give an overview on a library of Pd objects (collection of Pd abstractions) that I have developed to enable interactive sonic expressions.

sound-abs.pd is a basic auxiliary abstraction to create objects that load and playback a single audio file (stored as a WAV file).

soundlist-abs.pd builds on the abstraction `sound-abs` and enables the implementation of the T-Object **Sound Event**. It provides operations to create a list of `sound-abs` objects, to control their individual playback and playback volume.

layer-abs.pd builds on the abstraction `soundlist-abs` and is an auxiliary abstraction of the abstraction `ambient-abs`. It extends `soundlist-abs` objects with attributes to organize random playback of audio files with pause intervals.

ambient-abs.pd builds on the abstraction `layer-abs` and enables the implementation of the T-Object **SoundCarpet**. Instances are is initialized with any number of `layer-abs` objects and provide operations to organize their random playback.

gaitbeat-abs.pd builds on the abstraction `soundlist-abs` and enables the implementation of the T-Object **WalkBeat**. It provides operations to synchronize a stream of events with the playback of audio files (stored in a `soundlist` instance). Furthermore, each instance offers setting options for how to handle incoming events and how to map it to audio feedback. For instance weather to start with every incoming event the playback of the same audio file or to change to a different audio file every second event.

To use the objects described above, a main patch (GKmain.pd) has been implemented with operations to create instances of the abstractions described above and to forward incoming data to them. This main patch includes one `soundlist-abs` object and four `gaitbeat-abs` objects. Further, the main patch includes two sub-patches for dynamically creating objects of the type `ambient-abs` and `layer-abs`. Two further sub-patches are included with operations for initialising and managing objects of the type `ambient-abs` and `layer-abs`. Finally a last sub-patch provides an overview on the operations of all abstractions. The collection of Pd patches can be found using the follwoing link:

https://gangklang.gangs-of-bremen.de/puredata/

Incorporation of the Patches in iPhone applications

In order to use Pd as a sound engine in development of iPhone applications the libpd library has been used [2]. Within the iPhone application, the component Audio Controller is used to load the main Pd patch and to send messages to its objects. On application start, the required audio files are loaded. At runtime, consequent events (e.g. step event) are sent to the objects of the main patch. According to their specific type, the objects convert received events into timing, adjustment and playback of audio files.

[2] until 2015 Objective-C was the basic programming language to develop application for the iPhone, afterwards the programming language Swift has been introduced.