

PhD

THESIS SERIES

TAN LIANG

An Embodied Approach to the Analysis and Design of
Interactive Ambient Media

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Regarding the concept of Cognitive Linguistics, languages reflect how people think and our thought is grounded in people's bodily experiences with physical environments. This research explores how embodied thinking supports the development of new design methodologies that facilitate the experiences of actively participating audiences in interactions with ambient media. Based on the theories of embodied cognition and cognitive semantics, this research focuses on developing an embodied approach to analysing and designing ambient media through a series of studies. To understand audience experiences with ambient media and develop an approach to embodied interaction design, an in-depth discussion clarifies and synthesises the findings from three studies, whereby the implications are summarised with a view to informing further research and design practice. Three combinations of various perspectives offer new theoretical and methodological insights for research on embodied interactions. A set of guidelines for designing ambient media is proposed, providing methodological insights and strengthening the proposed approach.

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**AN EMBODIED APPROACH TO
THE ANALYSIS AND DESIGN OF
INTERACTIVE AMBIENT MEDIA**

TAN LIANG

PhD

The Hong Kong Polytechnic University

2019

The Hong Kong Polytechnic University
School of Design

**An Embodied Approach to the Analysis and Design
of Interactive Ambient Media**

TAN Liang

A thesis submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

September 2018

Certificate of Originality

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where acknowledge has been made in the text.

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Abstract

As digital computing and embedded technologies are increasingly pervasive and accessible in public spaces, interactions with technology-mediated physical environments become the focus of a growing amount of research in human-computer interaction (HCI). The paradigm of interaction design continually shifts from usability-oriented design to experience-centered design. Much research suggests that it is important to develop new knowledge that supports understanding and designing quality experiences in interacting with everyday environments. Moreover, embodiment is widely accepted as a theoretical foundation in HCI and emphasizes that human cognition is largely shaped by the body's interactions with the world. Influenced by the theory of embodied cognition, cognitive linguistics believes that languages reflect the way of how people think, and that thought is grounded in people's bodily experiences with physical environments. The embodied nature of the mind, experience and language underlie the foundation of this research's theoretical and empirical explorations.

Despite the increase in scholarly interest in hedonic, meaningful, and embodied experiences in HCI, there exists less work investigating the relationship between bodily interaction and meaning making in the context of ambient media. This research aims to explore how embodied thinking may support developing new design methodologies that aim at facilitating the experiences of audiences who actively participate in interactions with ambient media. Building on the theories of embodied cognition and cognitive semantics, this PhD research concentrates on developing an embodied approach to analyzing and designing ambient media through a series of studies.

With the aim of understanding audience experiences with ambient media and developing an approach to embodied interaction design, this research mainly comprises three progressive studies: a case study on ambient media works, an empirical study on audience experiences, and a study on designing ambient media. After a comprehensive literature review on ambient media, embodiment and audience experiences, a theoretical framework is built to lay the research foundation (Chapter 2). Subsequently, the methodological considerations and research design are discussed according to the research questions and objectives (Chapter 3). In the next chapter, 10 cases of ambient media are analyzed based on an analytical model that is devised from the theoretical framework (Chapter 4). Based on the preliminary findings from the case analyses, an in-depth empirical study on embodied interactions is conducted to understand key factors that define audience experiences with ambient media, as well as the mechanism reflecting bodily engagement and meaningful experience (Chapter 5). Next, the findings from the case study and the empirical study are synthesized as design strategies and models, which are subsequently applied to develop a range of ambient media designs. The design ideas are analyzed based on two analytical models derived from the previous findings. Experience tests on a physical prototype of a design idea are conducted for evaluation (Chapter 6). The design experiments indicate that the approach offers promising and applicable guidance in designing ambient media based on the idea of embodied interaction. Furthermore, based on two main aspects of this research: understanding audience experiences and designing embodied interactions, an in-depth discussion clarifies and synthesizes the findings from the three studies. The implications are summarized in view of informing further research and design practice. Three combinations of various perspectives offer new theoretical and methodological insights for research on embodied interactions. A set of guidelines for designing ambient media is proposed, which provide methodological insights and strengthen the proposed

approach (Chapter 7). Finally, the limitations of this research and suggestions for future research are discussed (Chapter 8).

Publications

Tan, L. and Chow, K.K.N. (2018). *Coupling Environmental Affordances with Schematic Meaning: A Matrix for Designing Embodied Interaction in Public Spaces*. In Proceedings of the Sixth International Symposium of Chinese CHI ACM, Montreal, Canada. <https://doi.org/10.1145/3202667.3202682>

Tan, L., & Chow, K.K.N. (2018). An Embodied Approach to Designing Meaningful Experiences with Ambient Media. *Multimodal Technologies and Interaction*, 2(2), 13. <https://doi.org/10.3390/mti2020013>

Tan, L. and Chow, K.K.N. (2017). *Piano Staircase: Exploring Movement-based Meaning Making in Interacting with Ambient Media*. In IFIP Conference on Human-Computer Interaction (Interact 2017) Springer, Mumbai, India, 282-291. https://doi.org/10.1007/978-3-319-67744-6_19

Tan, L. and Chow, K.K.N. (2017). *Facilitating Meaningful Experience with Ambient Media: An Embodied Engagement Model*. In Proceedings of the Fifth International Symposium of Chinese CHI ACM, Guangzhou, China, 36-46. <https://doi.org/10.1145/3080631.3080638>

Tan, L. and Chow, K.K.N. (2016). *An Embodied Interaction Framework for Facilitating Audience Experience with Ambient Media*. In the Fourth International Conference on Design Creativity (4th ICDC), J. Linsey, M. Yang and Y. Nagai Eds. The Design Society, Atlanta, GA, USA, 1-8. (ISBN: 978-1-904670-82-7)

Tan, L. (2015). Affordances: An Exploration on the Interaction Process in Experiencing Ambient Media. *Art Journal*, 88(1), 107-112.

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(Above papers were published during the PhD study. Parts of these publications are included in the thesis.)

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Chapter 1. Introduction

1.1 Background and motivation

1.2 Research questions and objectives

1.3 Methodology

1.4 Significance

1.5 Thesis structure

This research explores the analysis and design of interactive ambient media from the perspective of embodiment. It focuses on understanding how people experience mediated environments through bodily and situated interactions, and how ambient media can be designed to facilitate meaningful interactions and engaging experiences. This chapter provides an overview of the research by introducing the research background and motivation, the research questions and objectives, and the methodology and thesis structure.

1.1 Background and motivation

Nowadays, people's daily lives are pervaded by digital computing, for instance in workspaces, travel and commercial spaces. Everyday environments are imbued with different types of information, most notably as a result of the popularity of mobile devices such as smart phones. According to a report from Stanford University, people's attention tends to be constrained to the bright screens (TheOnion, 2009), and they spend most of their waking time focusing on the glowing screens of a variety of devices, including mobile phones, televisions, and desktop and tablet computers. While this new habit of staring at glowing screens has become a common phenomenon in daily life, people also constantly experience the data explosion and information overload all the time. Every minute, Facebook users produce 2.5 million pieces of

information, while 200 million emails are sent all over the world, and Twitter generates 300,000 messages (Gunelius, 2014). Surrounded by a flood of information, people are likely to face potential “attention deficit trait”, which refers to people’s loss of attention due to the distraction caused by receiving numerous messages (Dalbudak & Evren, 2014). In contrast to screen-based digital media, ambient intelligence (see section 2.2.2) embeds technology in physical environments and supports interactions in living, work, and public spaces. Interactive ambient media shift everyday objects and environments into novel interactive forms that actively engage people in situated interactions and facilitate meaningful experiences (Alves et al., 2010; Lugmayr, 2012; McCullough, 2013; Stalder, 2011).

In addition, this research is also motivated by two emerging trends in HCI. First, a growing amount of research in HCI suggests that the scope of interaction design should extend from digital artifacts to everyday environments in which digital computing can be integrated into physical spaces to facilitate intuitive and meaningful interactions (Hespanhol & Tomitsch, 2015; Kaptelinin & Bannon, 2012; Lugmayr, 2012; McCullough, 2013). Sensors, digital computing, mobile networks and cameras are increasingly pervasive and accessible in public spaces, in which they mediate people’s everyday social and tangible experiences. Ambient media incorporate interactive technology into physical spaces and creates various affordances for engaging audience in bodily and social interactions. The concept of “ambient” has a phenomenological backdrop, and embodied interactions are grounded in humans’ intrinsic familiarity with “ambiently embodied interfaces” (McCullough, 2004). Ambient media is considered as a novel media form that can elicit engaging experiences and facilitate meaning making by employing and transforming existing physical objects or spaces in everyday environments. Second, while the paradigm of interaction design continually shifts from usability-oriented design to experience-centered design (Hassenzahl et al., 2010; Pucillo &

Cascini, 2014; Wright & McCarthy, 2010), many researchers concentrate on investigating the emotional, hedonic, and meaningful aspects of experience with products and interactive systems (Desmet & Hekkert, 2007; Diefenbach & Hassenzahl, 2011; Dourish, 2001; McCarthy & Wright, 2004; Von Saucken & Gomez, 2014). Experiencing technology is a meaning making process that constitutes people's "felt life" (McCarthy & Wright, 2004, pp. 17-18). Furthermore, a growing amount of research dedicates attention to the role of the sensory-motor actions in comprehending languages (Gibbs & Wilson, 2002), experiencing digital media (Antle et al., 2011; Bilda et al., 2008; Chow et al., 2016; Hurtienne, 2017) and products (Van Rompay & Ludden, 2015), and playing digital games (Bianchi-Berthouze et al., 2007).

Despite the growing research interest in hedonic, meaningful, and embodied experience in HCI, little work has been done to investigate how bodily interactions can facilitate meaningful experience with ambient media, and how a design approach can be built to support understanding and designing embodied interactions with ambient media.

Departing from the critique that classical cognitive science is typically centered on internal processes, embodied cognition contends that cognitive processes are largely shaped by the body's states and that the mind is grounded in the body and its interactions with the world (Dreyfus, 1996; Varela et al., 1991; Wilson, 2002). Building on phenomenology, embodied interaction emphasizes that meaningful interactions between humans and machines are tightly coupled with both physical habits and social practices (Dourish, 2001). This coupling is actually in line with Dreyfus's three ways of understanding embodiment: through the body's innate features, through bodily skills, and through cultural habits (Dreyfus, 1996). They determine how people perceive and act in different environments, and how they make sense of the world. Embodiment in cognitive science has strongly influenced the

emergence of cognitive linguistics, and there is an underlying relationship between bodily experience, language and mental life (Evans & Green, 2006). Many embodiment-based studies (e.g., Antle et al., 2011; Bakker et al., 2012; Chow, 2016; Garde-Perik et al., 2013; Hornecker & Buur, 2006) indicate that embodied thinking provides an insightful perspective in understanding the interaction between users and interactive systems, especially in the studies related to bodily, tangible, and meaningful interactions. The embodied grounding of human experience and mind forms the foundation of the theoretical and empirical investigations in this research. One important property of ambient media is spatiality, which means that the physical public space is employed as the basis for interaction design. This is in line with the central idea of embodied cognition which believes that human cognitive processing is inherently grounded in bodily experience with the physical world. On the other hand, “ambient” has an underlying nature of embodied experience connecting bodily skills with physical environments. From the perspective of ecological psychology, the affordances of the physical environment provide various possibilities for eliciting bodily action. Therefore, the theories of embodied cognition provide a new perspective to understand ambient media design. Building on the theories of embodied cognition and cognitive semantics, this PhD research aims to develop an embodied approach to the analysis and design of ambient media.

1.2 Research questions and objectives

With the aims of understanding audience experiences with ambient media and developing an embodied approach to ambient media design, this research addresses the following two main research questions (RQs):

RQ1: How can audience experiences with ambient media be understood from an embodied cognition perspective?

RQ2: How can a design approach be developed to support embodied interactions with ambient media?

The two RQs are closely interrelated. Developing an embodied approach relies on an in-depth understanding of people's experience. The first RQ guides the research to investigate the main characteristics of audience experiences in interacting with ambient media, as well as the mechanism of embodied engagement, which helps to identify the key variables of ambient media design and provides qualitative guidance for approaching RQ2. The RQs as the core components determines the specific research objectives and methodology.

More specifically, a range of sub-questions are also addressed:

- 1) What theoretical framework can be established to support understanding audience experiences and exploring an embodied approach?
- 2) How can embodied interactions with ambient media be understood?
- 3) What major factors can be identified in people's experiences with ambient media?
- 4) Does bodily engagement facilitate meaningful experiences with ambient media and if yes, how?
- 5) What design strategies can be derived to support ambient media design?
- 6) How does an embodied design approach guide ambient media design and how can it be evaluated?
- 7) What implications of this research can inform future endeavors in the field?

Based on these RQs, the following objectives are formulated:

- 1) To establish a theoretical framework for supporting the analysis and design of interactions with ambient media.

- 2) To analyze ambient media cases for understanding the basic processes of the interactions between audiences and ambient media.
- 3) To create prototypes and conduct experiments to identify the main factors of embodied experiences with ambient media.
- 4) To investigate the mechanism between bodily engagement and meaning making in interacting with ambient media.
- 5) To develop an approach to designing embodied interactions with ambient media.
- 6) To design ambient media works by applying the design approach and evaluate the approach.
- 7) To propose theoretical and methodological implications for future research and formulate guidelines for design practice.

1.3 Methodology

The major aims of this research are to understand audience experiences, defined as multi-level responses elicited from people's active participation in interactions with ambient media (see p. 46), and to develop an approach to designing embodied interactions with ambient media. In this regard, this research mainly follows an interpretive paradigm and adopts a qualitative methodology by combining interpretive analysis and research through design. Interpretivism is inherently grounded in phenomenology, especially hermeneutic phenomenology. From a phenomenological perspective, understanding audience experiences requires describing and interpreting meaning from subjective experiences, as well as a phenomenological approach that places the participants' perceptions, feelings, and experiences center stage within qualitative research (Groenewald, 2004). Research within the interpretive paradigm relies on the interpretation and observation of people's lived experience, and the roles of researchers can be observers, interviewers, analysts, and even participants. Interpretivists seek to

understand of the situations in which they live, and the participants' subjective attitudes and views of a situation, which are interpreted to construct meaning and develop theory (Creswell, 2007, pp. 20-21). On the other hand, this research also has some features of pragmatism. Researchers in design believe that design theories and assumptions should be continuously tested in practice in order to evaluate them (Dalsgaard, 2014). Experimental tests of participants' experience with ambient media in public spaces provide empirical evidence for developing and evaluating an embodied approach. Furthermore, *research through design* has been developed as an important methodology within the design research community (Gaver, 2012; Jonas, 2015; Zimmerman et al., 2007, 2010). Design researchers develop new knowledge through design practice, which is regarded as an approach of inquiry, which is in line with the idea of pragmatism that new knowledge is produced from direct engagement with a situation (Rorty, 1991, p. 1).

The methodology of this research combines interpretive analysis and research through design. Interpretive analysis is used to understand the experience with ambient media works, while thematic analysis is conducted to analyze verbal reports in empirical studies. Both interpretive and thematic analysis are inherently grounded in hermeneutic phenomenology, which offers a highly effective approach in eliciting personal experiences from the participant's perspective (Guest et al., 2012). Additionally, developing a design approach embodies the characteristics of exploratory research. Interaction design researchers contribute to new knowledge through iterative design development (e.g., prototyping and testing), which blurs the line between the roles of researcher and designer (Dalsgaard, 2014; Jonas, 2015; Zimmerman et al., 2010). Research through design is also a process of describing, interpreting, and reflecting on developing artifacts, and the reflections of researchers (designers) themselves can be a form of design

evaluation (Gaver & Höök, 2017). Based these methodological considerations, this research is mainly comprised of three closely interrelated studies: a case study on ambient media works, an empirical study on audience experiences, and a study on designing ambient media. These three studies constitute a tight and progressive research structure, as each study develops new models that support the next study in order to conduct interpretive analyses and experience tests following both deductive and inductive processes.

1.4 Significance

As an exploratory project, this research contributes to the knowledge of understanding audience experiences and designing embodied interactions with ambient media. The significance of this research is three-fold, bearing on the fields of design research, design practice, and design education. First, this research represents an important step in advancing the theories and methodologies of embodied interaction and ambient media design. Based on both interpretive and empirical studies, the findings provide systematic guidance for the analysis and design of ambient media in regard to embodied meaning making. The models and implications form a basis for broadening the body of knowledge on embodied interaction and designing for meaningful experience.

For design practice, a set of analytical models and design strategies are formulated and applied to design experiments in the study of designing ambient media, and three design principles are also summarized in the discussion chapter. These models, strategies, and principles can guide designers in developing design ideas and analyzing audience experiences throughout the design process. In addition, the embodied approach to ambient media design can be applied to brand experience design, museum exhibit design, and public space design.

Third, this research provides rich content for design education, especially for the discipline of interaction design. The interpretive analysis on ambient media cases and the empirical data from experience tests can be used by teachers as practical examples in teaching experience design. The design strategies and principles can be employed as design thinking tools in related courses. In its combination of case analysis, empirical study, and design experiments, the research design offers a useful model for postgraduate education in interaction design.

1.5 Thesis structure

Chapter 1 offers an overall introduction to the research and highlights its main points.

Chapter 2 comprehensively reviews the literature on embodiment, experience with ambient media, and affordances, based on which a theoretical framework is built. This framework forms the basis for informing further interpretive and empirical studies on understanding and designing embodied interactions with ambient media.

Chapter 3 examines the methodological considerations, thereby aiming to construct a research design according to the RQs and study objectives. The interpretive paradigm and qualitative methodology are proposed as the main methodological guides in developing an approach to the analysis and design of ambient media.

Chapter 4 analyzes a set of ambient media cases based on an analytical model devised from the theoretical framework. The case analyses give rise to a

preliminary understanding of embodied interactions with ambient media, which provides further insights for empirical investigations.

In Chapter 5, an in-depth empirical study is conducted on participant's experience with an ambient media work, thereby aiming to understand the key factors that define audience experiences with ambient media, as well as the mechanism between bodily engagement and meaningful experience.

Chapter 6 reflects on and synthesizes the findings from the case analyses and empirical study to develop an embodied design approach, which is subsequently applied to develop a range of ambient media designs. Experience tests on a designed physical prototype are conducted to validate and strengthen the approach.

Chapter 7 discusses the findings from the three studies in regard to other related studies. The design experiments indicate that the approach offers promising and applicable guidance in designing embodied interactions with ambient media. Subsequently, a set of guidelines for designing meaningful experience is proposed, which provides methodological insights and strengthens the approach. Based on interpretive analysis, empirical investigation, and reflection on design experiments, the discussion proposes a range of characteristics of ambient media design, which offer new theoretical insights for analyzing and designing embodied interactions with ambient media in future research.

Chapter 8 concludes by summarizing the main findings. It also states the limitations and contributions of this research, and makes recommendations for further research on embodied interaction and ambient media design.

Chapter 2. Literature Review

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2.2.2 Related concepts in HCI

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2.2.4 Properties of ambient media

2.2.5 Various approaches to ambient media research

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2.5 Theoretical framework

2.1 Introduction

The literature review presented in this chapter has three main purposes. First, it aims to establish a theoretical framework to support and inform further studies on the analysis and design of ambient media by examining relevant concepts, theories, and variables, as well as the assumed relationships between them. Especially, the theories on embodied cognition and cognitive semantics provide the investigation on ambient media design with new insights and help to develop the RQs and methodology. Second, this chapter

aims to define the scope of the research by reviewing and clarifying relevant concepts (e.g., ambient media and audience experiences). Third, although embodied thinking provides the HCI community with valuable insights for understanding user experience, only a few studies focus on developing embodied methodologies to guide design practice. Related studies on embodied approaches in HCI are examined to provide this research with valuable references.

Regarding the three purposes, the literature review primarily consists of three themes: ambient media, embodiment, audience experiences, within which a range of key concepts and studies are examined, and the main RQs are developed. Based on a comprehensive literature review, a theoretical framework is established to support and guide the body of this research.

2.2 Ambient media

Aiming to define the specific scope and characteristics of ambient media within the present research context, this chapter first examines different views and terms related to the concept of “ambient media,” thereby drawing from several disciplines, such as marketing, design, and HCI. The definitions are subsequently compared in view of gaining a better understanding of ambient media.

2.2.1 Ambient-related concepts

In recent decades, the “ambient”-related concepts draw increasing attention from research communities, but various terms are used in regard to specific fields, including “Ambient Media” (Austin & Aitchison 2003; Hutter & Hoffmann, 2014; Lugmayr, 2012; Shankar & Horton, 1999), “Ambient Advertising” (Abdul-Razzaq, 2009; Jurca, 2012; Luxton & Drummond, 2000), “Ambient Marketing” (Bargenda, 2015; Lee & Dacko, 2011), “Ambient

Communication” (Biraghi et al., 2015; Rosengren et al., 2015), “Ambient Displays” (Vogel & Balakrishnan, 2004) and “Ambient Intelligence” (Aarts & Encarnação, 2006; Alves Lino et al., 2010). According to the searching results from Google Scholar, “Ambient Media” is the second most frequently used term with around 7860 results (exact match) mainly coming from marketing and ubiquitous computing, while “Ambient Intelligence” gets the most results with 62,000 (results on Dec. 15, 2017).

In its literal meaning, “ambient” is defined as “of or relating to the immediate surroundings” (Collins English Dictionary, 2014) and “of the surrounding area or environment” (Random House, 2010). In interaction design, “ambient” usually refers to the environment that physically and immediately surrounds people. McCullough (2013) uses the term “ambient commons” to rethink how people deal with attention in the “information superabundance” of today’s environments, in which the immediate surrounding can form a basis for making digital technology more embodied and intuitive. McCullough also mentions that the popularity of the term “ambient” in recent decades is due to its wide use in the advertising industry, though his book’s emphasis is on pervasive computing and interaction design. This section starts with a review of related concepts in advertising and communication research.

The concept of ambient media is first used for advertising campaigns by Concord Advertising, a UK advertising agency devoted to outdoor advertisement (Shankar & Horton, 1999). Although the term is mentioned in several studies (e.g., Atcher, 1998; Concord, 1999), there is a lack of systematic analysis and explicit definition. Probably, Shankar and Horton (1999) make the first attempt to study ambient media at an academic level. Their study attempts to introduce the concept of ambient media to the advertising research field, defining ambient media as “non-traditional out-of-home” media. It adopts a typological approach to describe and classify ambient

media, and categorizes the uses of ambient media in a range of contexts, such as leisure, travel, and enterprise, whereby objects and locations are used as vehicles to convey branding information. This understanding highlights the usage contexts of ambient media.

Luxton and Drummond (2000) propose that location, execution, and temporal issues are three key attributes of “ambient advertising.” Departing from these factors, the authors formulate a definition of ambient advertising: “placement of advertising in unusual and unexpected places (location) often with unconventional methods (execution) and being first or only ad execution to do so (temporal).” This definition considers that ambient advertising is created in unexpected locations and in unconventional ways at a certain time. The key attributes differentiate ambient advertising from traditional outdoor advertising, as previous views failed to clarify the difference between them in terms of certain criteria (i.e., location, execution, and temporality).

In the book *Is Anybody Out There?*, Austin and Aitchison (2003) define ambient media as one of the “non-traditional new media” and “anything appropriate that can deliver an advertising message. Anything you can write on, draw on, paint on, or hang something on. Anything you can borrow or subvert to deliver a brand contact.” Ambient media are divided into two types namely “structured ambient media” and “unstructured ambient media.” The former refers to physical architectural spaces (e.g., floors, building facades, and car-park gates), while the latter refers to the scenarios created by the designer, such as a lung-shaped ashtray denoting the health hazard of smoking.

According to Lee and Dacko (2011), “ambient marketing” is “Alternative out-of-home marketing communications methods which employ non-traditional physical spaces or objects that are not typically designated to carry advertising

messages, and which are located within consumers' immediate external environment." Compared with the previous views, this definition proposes that ambient media can reduce advertising avoidance due to their embeddedness in the daily spaces and objects that allow the target audience to engage and interact with them. Ambient media draw upon existing or commonplace objects within the environment to create physical affordances and embodied interactions for the audience, whereas traditional media such as large billboards and posters are unable to achieve this level of effectiveness. Lee and Dacko (2011) consider that there are two types of interaction between the audience and the media: passive interaction and active interaction. For instance, a person standing on an escalator that is designed as an ambient medium passively interacts with the environment. In contrast, a person who is attracted by a digital image projected on the floor and walks around on the mediated floor is someone whose innate bodily skills (walking around) are actively involved in the interaction with an ambient medium.

A more explicit conceptual framework of ambient media is proposed by Jurca (2012). She describes it as a media form with unconventional and creative features which can express brand or product information by utilizing the existing features of spaces to bring unexpected experiences to the audience. She also presents four criteria of ambient advertising: involving creative design, exploiting environmental elements, bringing surprise to the audience, and delivering direct or contextual information.

2.2.2 Related concepts in HCI

The concept of ambient media is also adopted in HCI and ubiquitous computing (Aarts & Encarnação, 2006; Alves Lino et al., 2010; Lugmayr, 2012; Mustaquim, 2014; Vogel & Balakrishnan, 2004). In the context of HCI, ambient media is defined as a media interface that combines physical space, intelligent technology, and sensory data to actively engage people in communicating

virtual information in a physical setting (Lugmayr, 2012). This claim emphasizes that ubiquitous technology is embedded and hidden within everyday environments for people to intuitively use it and to reduce the burden of cognition. Mustaquim (2014) proposes a framework for inclusive design from the perspective of ambient media and discusses how the principles of intelligent interface design can enhance user experience in ambient media.

Ambient intelligence and responsive environments are two fields that are closely related to ambient media. Ambient intelligence refers to digital technology-enhanced environments that actively perceive and support people's daily activities (Augusto et al., 2010), thereby combining electronic engineering, computer science, HCI, and cognitive science. The term "ambient" in ambient intelligence refers to the physical environment that is embedded within the technology to support interaction in a natural and intuitive way (Aarts & Encarnação, 2006). The term "responsive environment" is coined by Myron Krueger, who focuses on developing interactive art installations in public spaces in which the responsive environment outputs real-time auditory and visual feedback according to people's behavior (Krueger, 1977). Alves Lino et al. (2010) advance Krueger's definition by combining responsive environments with ambient intelligence, whereby responsive environments are defined as environments that are embedded with ambient intelligence to facilitate a rich and interactive user experience. Salem et al. (2017) propose a framework comprising a range of dimensions (e.g., architecture, technology, and modalities) for understanding and designing responsive environments.

2.2.3 Defining ambient media

Table 2.1 compares various definitions and their main elements. Overall, the first five definitions are classified into marketing fields, while the last three are

mainly related to HCI research. Despite the differences in their various applications and elements, these concepts provide a broad perspective on ambient media for the present research. In regard to the research background and questions (see Chapter 1), this study defines ambient media as follows:

A novel media form that engages people in embodied interactions and facilitates meaningful experiences by employing and transforming existing physical public environments.

The definitions of Alves Lino et al. (2010), Jurca (2012), and Lugmayr (2012) identify three key properties of ambient media: spatiality, unexpectedness, and engagement, thereby positioning their research within the particular context of embodiment and meaning making. Conventional media mainly refer to paper-based media (newspapers and magazines), electronic media (television and radio), digital media (the internet and mobile devices), and conventional outdoor media (posters and billboards). In contrast to these media forms, ambient media are differentiated based on the three properties mentioned above. First, ambient media are situated and integrated in public space rather than in paper-based or digital media. Second, people are engaged in active bodily interaction with ambient media rather than in passive information reception. Finally, interacting with ambient media can elicit unexpected and embodied experiences rather than merely send perceptual messages (e.g., through a video or poster). The three properties are elaborated in the next section.

Researchers	Definitions	Key elements
Shankar and Horton (1999)	Ambient Media: Non-traditional out-of-home described in terms of seven scenarios	Environments
Luxton and Drummond (2000)	Ambient Advertising: The placement of advertising in unusual and unexpected places (location) often with unconventional methods	Location, execution and time

	(execution) and being first or only ad execution to do so (temporal)	
Austin and Aitchison (2003)	Ambient Media: Non-traditional new media and anything appropriate that can deliver an advertising message. Anything you can write on, draw on, paint on, or hang something on. Anything you can borrow or subvert to deliver a brand contact.	Physical objects or environments being transformed
Lee & Dacko (2011)	Ambient marketing: Alternative out-of-home marketing-communication methods employing non-traditional physical spaces or objects that are not typically designated to carry advertising messages and are located within consumers' immediate external environment.	Engagement and interaction
Jurca (2012)	Ambient advertising: An unconventional form of advertising based on creativity that can convey direct and contextual messages by using and transforming existing elements of the environment in a way that surprises the target audience.	Creativity Drawing on environments Surprising target audience Transmitting message
Lugmayr (2012)	Ambient media: A media form that is embedded in people's everyday environment, whereby contextual information is delivered through hidden pervasive technology for people intuitively interacting with the environment.	Ambience Invisible technology Intuitive use
Augusto et al., 2010	Ambient intelligence: a digital technology-enhanced environment that actively perceives and supports people's daily activities, combining electronic engineering, computer science, HCI, and cognitive science.	Multidisciplinary technology Supporting daily lives
Alves Lino et al. (2010) Salem et al. (2017)	Responsive environments: adaptive environments embedded with ambient intelligence to facilitate a rich user experience and support natural interaction.	Embedded technology User experience Natural interaction

Table 2.1 Summary of concepts related to ambient media

2.2.4 Properties of ambient media

2.2.4.1 Spatiality: public space

Several researchers (e.g., Lee & Dacko, 2011) consider the out-of-home element as a characteristic of ambient media, thereby emphasizing locations as a major concern. This may not accurately define ambient media but does indicate an important attribute: spatiality. Spatiality in this research refers to ambient media's use of everyday public space as an interaction interface by transforming its existing functions or forms. While "space" in the context of design refers to physical and tangible property, "public" is a social concept. To identify the extent to which ambient media are public requires a consideration of the opposite term, "private," in which experience is characterized by privacy and intimacy (e.g., in the home or personal office). One factor distinguishing private space from public space is ownership. In urban planning, public space is usually deemed as outdoor space owned by the government (e.g., an urban square, road, or park), while private space belongs to individuals or institutions (Xing, 2013, p. 46). This classification may not accurately define the specific scope of public space for ambient media, as many indoor environments (e.g., airport terminals) are public spaces and some outdoor public areas are owned by private organizations. From the perspective of accessibility, public space is regarded as the areas in the artificial and natural environment that are freely accessible to all people (Carmona et al., 2008). It includes exterior open spaces (e.g., a street, park, or square) and interior spaces (e.g., an airport terminal, shopping mall, university, or library). In addition, the boundary between public and private is not always absolutely distinct, as public space can be understood as a sphere anyone can see and hear and an area that can be shared between people and connect people's personal lives. Some public spaces are partially restricted (e.g., by opening times or age), whereby the term "semi-public space" (e.g., the

theatre, library, or office) is used to describe such an in-between state (Miessner, 2012).

Another dimension of public space is scale, which concerns the size of the public space with which the audience interacts. Mak (2008) distinguishes three scales of public space: the human scale, the building scale, and the city scale (Figure 2.1), illustrating the various relations they facilitate between people and spaces. Most ambient media are created as part of a space, for instance a staircase, bus stop, or artifact (e.g., a trash can), that is in line with the scale of the installation. The term “human scale” is also used by Burke (2016) to emphasize that the size and form of the built environment with which people interact is suitable for daily use. Only a few ambient media reach building scale and city scale.

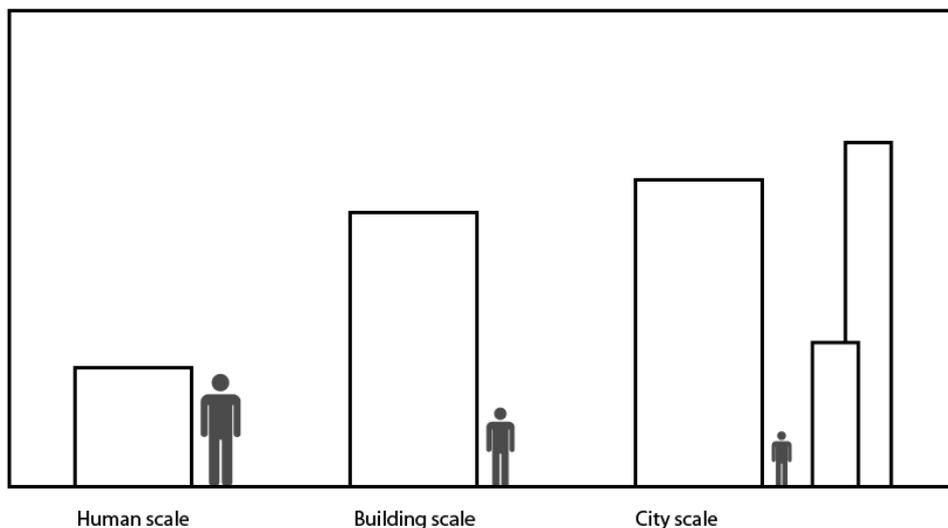


Figure 2.1 Scales of public space (adapted from Mak, 2008)

From the perspective of affordances, the physical features of public space can be employed to facilitate people’s action possibilities, following Gibson (1979), who believes that affordances as environmental features can invite human actions. Environmental elements such as light, spatial arrangement, and shapes can be used as sensory features for engaging people in interaction,

which can effectively enhance the audience's experience. In contrast, traditional media such as billboards and posters are unable to engage the audience because they lack action possibilities. To a large extent, people's activity in the physical environment is contextualized by the situational resources that are available, which allow the audience to associate the spatial features with a certain intended meaning or object (Sundaram & Rikakis, 2006). For example, Lenovo Flexible Door (Kim, 2011) is an ambient media work that employs the door of a main entrance as the basis for design. The door is designed like a rotatable laptop that people have to push when entering a building. The door's physical features are combined with the product's characteristics to facilitate meaningful interaction rather than only functional interaction (opening the door to enter). The affordances of ambient media are further discussed in section 2.5.

2.2.4.2 Unexpectedness

Ambient media, usually considered as a form of media that is situated in unexpected places and with unconventional methods (Luxton & Drummond, 2000), can attract people's attention for engagement. Unexpectedness is regarded as an aspect of experience that is related to psychological responses that give rise to further emotional feelings (e.g., pleasant or anxious) (Hutter, 2015; Luxton and Drummond, 2000). McCarthy and Wright (2004) mention that one most prominent features of interaction with technology is its potential to give rise to surprising and creative experience, which inherently exists in every moment of interaction and makes every experience unique. Moreover, unexpectedness is about serendipity, which refers to people's spontaneous discovery of unexpected things, including the when, where, who, and what of an experience (Liang, 2012). Serendipity can be viewed as a design resource that creates meaningful unexpectedness through interactions in our everyday lives. Therefore, unexpectedness is not only a cognitive phenomenon but also a stimulus by which to generate meaning and

action possibilities. In contrast with past experience, surprise can strengthen emotions such as joy or anger. New and unexpected stimuli can surprise people when they do not fit their expectations. Triggering a surprise effect is an important means of attracting people’s attention to ambient media (Hutter & Hoffmann, 2014).

The theory of “schema incongruity” (Mandler, 1982), originally used to analyze the relationship between evaluative cognition and emotion, is applied to investigate ambient media’s effectiveness and unexpectedness (Jurca & Madlberger, 2015). When novel and unexpected designs (regarding location and method) are incongruent with the audience’s scope of familiarity (or expectation), they fail to surprise the audience, whose emotional intensity and cognitive effort largely depend on the level of incongruity. According to the model (Figure 2.2) proposed by Mandler (1982), if the mismatch is moderate, the audience is more likely to assimilate it, which may result in positive feelings. However, if the incongruity is severe and the audience is unable to interpret a design correctly, this may generate negative emotions.

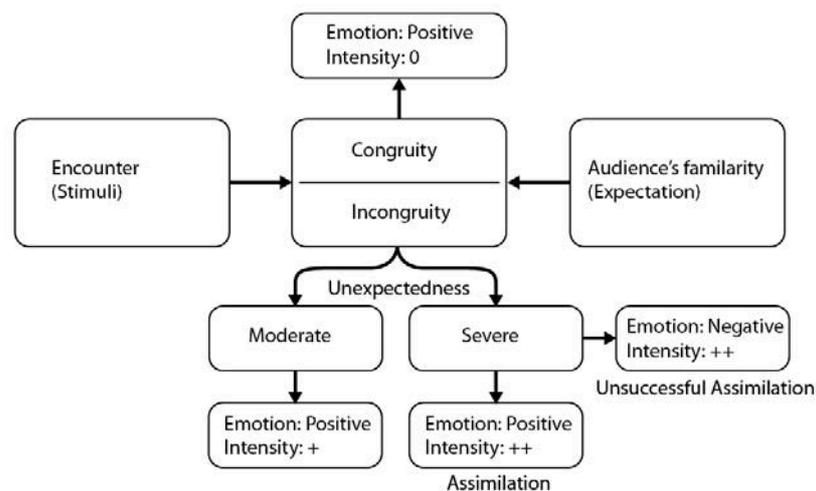


Figure 2.2 Schema Incongruity adapted from Mandler (1982)

2.2.4.3 Engagement

Engagement is regarded as people's motivation to participate in interaction with technology or the psychological response of desire to become involved in an activity (O'Brien & Toms, 2008). People's engagement with ambient media makes it possible for advertising companies to build and understand consumer-brand relationships by eliciting multi-sensory experience (Hulten, 2011). From an embodied perspective, cognition and meaning are generated from direct and bodily engagement with the world (Anderson, 2003; Heft, 1989). Engagement is the source of meaning making and sharing in the interaction between people and the world (Dourish, 2001, p. 126), and people's bodily movements increase their level of engagement in interacting with digital games (Bianchi-Berthouze, 2013). O'Brien and Toms (2008) formulate an engagement framework for understanding user experience with websites in terms of the interaction process, which comprises four basic phases: start of engagement, sustained engagement, exit of engagement, and restart of engagement. This model is used to understand people's experience with online technology and can be applied to analyze embodied interactions with ambient media. However, this model is intended for task-oriented and screen-based interactions, and dedicates less consideration to the role of bodily actions in engagement.

Ambient media not only provide new visual and auditory content, as is the case for traditional media (e.g., posters or TV), but also make use of existing physical objects or spaces in everyday environments to create possibilities for direct venue-based engagement. In other words, the most prominent feature of ambient media is that they can engage the audience's bodily actions by providing physical affordances that allow for interaction between the audience and the environment. The notion of "mechanism of engagement" (Chow, 2010, p. 101) provides a useful perspective to analyze user's engagement with interactive media, whereby immediate engagement refers to instant (rather than continuous) action or participation. Striking a computer

keyboard is an immediate engagement, in which every action or gesture is clearly halted after it takes place. Continuous engagement occurs when the action is like a flow, in which actions continue without an obvious stop. In addition, Lee and Dacko (2011) distinguish between proactive and passive engagement. These views inform the analysis of experience with ambient media in this research.

2.2.5 Various approaches to ambient media research

As Section 2.2.1 and Section 2.2.2 review, different approaches are adopted by related studies on ambient media, which provides diverse perspectives to understanding and designing interactive ambient media. Jurca and Madlberger (2015) draw upon schema congruity theory as a theoretical basis to investigate the effectiveness of ambient media. As Section 2.2.4.2 reviews, Mandler (1982) originally uses schema incongruity theory to analyze the relationship between cognition and emotion in evaluation, is applied to investigate ambient media's effectiveness and unexpectedness. The extent of incongruity affects a person's overall feelings about the experience. Based on the approach, a conceptual framework is established for further empirical studies on the effectiveness of ambient media. A study on ambient marketing employs a semiotics approach to analyze meaning making in ambient media (Bargenda, 2015). Based on the Peirce's triadic model, that study conducts two case analyses and considers that the spatial features of ambient media represent three types of signs in delivering meaning related to brands and corporations. A historical approach is followed to examine different previous views and concepts on ambient advertising (Lee & Dacko, 2011; Semenescu, 2013). Mixed-method approach is also used in some studies to evaluate the effectiveness of ambient media (Hutter, 2015; Sula; Rosengren et al., 2015), which combines content analysis and experimental study to understand and analyze locational and executional elements. These approaches have different focuses and specific research aims. However, no study follows an embodied

approach to researching ambient media. With regard to the three properties of ambient media identified above, an underlying relationship exists between them and embodiment, which is further discussed in latter sections.

2.2.6 Summary

In summary, this section clarifies the concept of ambient media based on the research background by examining related views from various disciplines. Ambient media aim to engage people through meaningful interaction by employing the physical features of public environments to solicit engaged actions. Regarding the RQs, three key properties of ambient media are identified: public space (spatiality) is discussed based on ownership, scale, and affordances, which provide references for identifying criteria in designing ambient media. The physical forms of ambient media can be designed to attract people's attention, to engage them in bodily interactions (engagement), and to elicit their unexpected responses (unexpectedness).

This research focuses on theoretically and methodologically exploring the analysis and design of ambient media rather than on specific applications of ambient media design, such as branding and environmental design. As mentioned in Chapter 1, the concept of ambient media is grounded in phenomenological traditions, due to its embodied nature. The next section reviews relevant literature in view of establishing an embodiment basis for understanding audience experiences and designing meaningful interaction with ambient media.

2.3 Embodied foundation of ambient media

In recent decades, embodiment is extensively discussed and studied in various academic fields, such as philosophy (Gallagher, 2005; Shapiro, 2010), psychology (Gibbs, 2006; Wilson, 2002), cognitive science (Anderson, 2003;

Varela et al., 1991), cognitive linguistics (Lakoff & Johnson, 1980), HCI (Dourish, 1999; Svanæs, 2013), and interactive media (Chow, 2013). The basic idea of embodiment is that human cognitive processing is fundamentally grounded in our sensory-motor experience with the physical world and that the human mind is shaped by the body's innate structure and everyday bodily actions. Mind, body, and environment are mutually connected and constitute a unity, whereby meaning is generated through the interaction between the body and its environment. This runs counter to Descartes' dualism, which proposes that the human mind is separated from the body and the world. The theories of embodiment originate in the phenomenological tradition. Merleau-Ponty focuses on the body's role in experience by examining empirical examples from experimental psychology (Merleau-Ponty, 1962), in which he was deeply influenced by other phenomenologists such as Husserl and Heidegger.

This section first looks back on these phenomenologists' insights and original thinking, and subsequently examines embodiment theories in cognitive semantics and embodied interaction. Next, relevant studies and approaches in HCI that are built on embodiment are reviewed. Finally, a theoretical framework is built in view of developing an embodied approach to the analysis and design of ambient media.

2.3.1 Phenomenological roots of embodiment

2.3.1.1 Husserl and intentionality

Phenomenology is an important branch 20th century philosophy. Although the origins of phenomenology can be traced back to Kant and Hegel, Husserl is recognized as the founder of phenomenology (Groenewald, 2004). Following Husserl, many philosophers, including Heidegger, Sartre and Merleau-Ponty, continue to extend and develop phenomenology. Phenomenology is concerned with how humans experience the surrounding world and make meaning in their experience (Dawson, 2013, p. 258), which

offers a wide perspective in understanding the relationship between mind, body, and world.

In Husserl's phenomenology, "intentionality" is a main feature of consciousness. It refers to the central structure of an experience as being directed toward something: an experience is always related to particular objects or events. The theory of intentionality aims to determine an act's meaning by interpreting the intentional nature of that act (Jacob, 2014; McIntyre and Smith, 1989; Smith, 2013). Inspired by Franz Brentano, Husserl is interested in exploring intentionality. Brentano adopts the term "intentional" from medieval philosophy. "Intentionality" originates from the Latin verb "intendere," which means "to point to" or "to aim at." Brentano considers that human existence is always directed toward something and is featured by the intentionality of mental states and experiences (Smith, 2013). As a fundamental notion within phenomenology, intentionality presents the underlying nature of our mental situations and experiences, such as perceiving, remembering, deciding, desiring, wishing, understanding, intending, and experiencing. The human mind is not only impacted by the external physical world but is also aware of other people and oneself, of abstract symbols such as numbers and formulas, and of things that exist in one's mind. Most human conscious activities have the specific feature of being "of" or "about" something, thereby showing a sense of something to us. For instance, when a person sees a flower, a flower is perceived. Therefore, "intentionality" is the representational character of the mind or consciousness and is always directed toward a certain thing (McIntyre & Woodruff, 1989).

2.3.1.2 Heidegger and Being-in-the-world

As Husserl's student and assistant, Heidegger studies many of Husserl's early theories. He develops his own ideas on phenomenology, primarily through his

influential work *Being and Time* (Heidegger, 1962). Heidegger uses the term “Being-in-the-world” in response to a debate on the body-mind relationship. Descartes argues that the world is made up of two elements: a mental domain (consciousness) and a physical domain (the world), which is external to the mental domain. The body is an object and a thinking machine, and the subject has an immaterial mind and a material body. This is known as Cartesian dualism. Heidegger resists the Cartesian view of the distinction between mind and body. In contrast, he believes that the relationship between mind and body exists in how people behave in everyday activities, such as using a hammer, and his phenomenology focuses on people’s contextual connections with things (Smith, 2013).

Being-in-the-world means people and their activities always exist in the physical world, and it comprises various philosophical terms such as subject, object, consciousness, and world. Heidegger contends that the question of splitting things into subject-object must be overcome, which also echoes the fundamental structure of Husserl and Brentano's notion of intentionality (directedness). His fundamental notion is that human beings exist as “Being-in-the-world” (Schreuder, 2014, p. 45). Heidegger devotes himself to challenging this question and uses the term “Dasein,” literally meaning “Being there,” but actually meaning “existence.” To describe experiences, one must begin with humans in the world (Cerbone, 2006), meaning that people exist and are always situated in a certain environment and that the mind cannot be separated from the world and other people. He believes that if phenomenology can explain the structure of “being in the world,” the focus must be on everyday activities.

On the other hand, although *Being and Time* makes significant progress compared with Cartesian dualism, Heidegger discusses few details about the bodily aspects of “Dasein.” He presents a number of concrete examples, such

as that of the carpenter and the hammer, but does not reveal how the structure of Dasein's "lively body" influences the form of Being-in-the-world. He does not adopt the perspective that the human body is an essential element in addressing the issue of the subject-object relationship in the tradition of Western philosophy. In *Being and Time*, Heidegger writes that "Dasein's 'bodily nature' hides a whole problematic of its own though we shall not treat it here" (Heidegger, 1962). He does not directly discuss the role of the lived body, and 'the body' was perhaps the most difficult problem for him (Cerbone, 2000).

2.3.1.3 Merleau-Ponty and embodiment

Informed by the insights of Husserl and Heidegger, Merleau-Ponty establishes his own interpretation of phenomenology. His seminal work *Phenomenology of Perception* (1962) focuses on the issues of perception and embodiment in exploring the relationship between mind, body, and world. He stresses that the body plays a central role in lived experience and how people experience the world. The body is the subject experiencing the world, as Merleau-Ponty claims: "Our own body is in the world as the heart is in the organism . . . I could not grasp the unity of the object without the mediation of bodily experience" (p. 235). People make sense of the world and gain knowledge through the body's direct and active perception of its environment, and consciousness is tightly connected to lived experience (Toadvine, 2016).

Embodiment is a key idea in Merleau-Ponty's work, which is primarily concerned with how we perceive, experience, and act in the surrounding environment. Merleau-Ponty closely studies Husserl's manuscript *Ideas II*, which inspires him and forms the foundation of his later investigations. The idea of embodiment runs counter to Cartesian dualism, and Merleau-Ponty's description of the body centers on two primary arguments: (1) the body is a particularly distinct category of thing and (2) the body plays a central role in

the structure involving the body in the experience of different types of objects. In other words, the human body is the medium of different perceptions. Merleau-Ponty also dedicates a significant amount of attention to analyzing the experience of space. He believes the body to be the starting point for understanding direction and space, and that the senses do not passively perceive space but rather that the body inhabits the world. Spatial understanding relies on the close collaboration between sensory perception and motor action (1962, p. 292). In comparison with Husserl, Heidegger, and Sartre, the most distinctive aspect of Merleau-Ponty's phenomenology is probably his efforts to adopt empirical research involving psychology, physiology, and linguistics. His empirical research emphasizes discovering the unexamined suppositions about the nature of experience, embodiment, and action (Cerbone, 2006). Merleau-Ponty's theories involve the active role of the body in human experience, which extends Heidegger's "Being-in-the-world" to "embodied being" by treating the body as "the vehicle of being in the world."

The term "intentional arc" denotes the close relationship between perception and action that underpins conscious thinking (Merleau-Ponty, 1962, p. 157). Merleau-Ponty analyzes a case in which a craftsman making a wallet perceives the objects and his body in a familiar environment in terms of his possibilities for action. Following Merleau-Ponty's thoughts, Varela et al. (1991) argue that cognition is shaped by sensory-motor interactions between the human body and the environment. Dreyfus (1996) proposes that repeated bodily practice can enable the human body to "absorb" bodily skills in its interactions with the environment and that these skills allow humans to intuitively perform certain tasks without much cognitive effort. The intentional arc constitutes an active cycle between perceptions, actions, bodily skills, and environments, which makes bodily actions occur below reflective consciousness (Chow et al., 2016; Dreyfus, 1996; Rietveld, 2008).

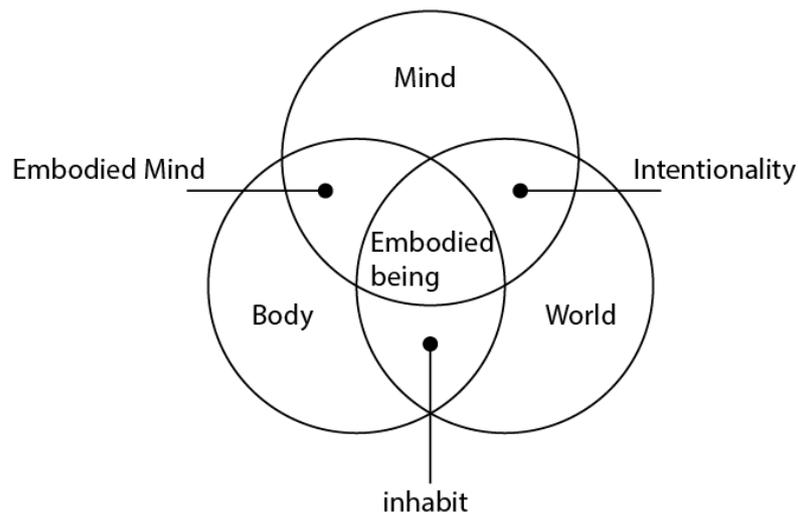


Figure 2.3 The relationship between mind, body, and world

Following these phenomenological insights, this study believes that mind, body, and world are inseparable as a unity. They are not separate entities but three mutually interrelated parts of human existence (Figure 2.3). The human mind is always directed toward certain things in the world (intentionality). Meaning is produced from the interconnection between motor action and sensory perception, and the mind cannot be isolated from the body (embodied mind). The body is not only “in” the world but also “inhabiting” its surrounding spaces through habitual movements and skillful coping (Dreyfus, 1996; Merleau-Ponty, 1962, pp. 160-161).

2.3.2 Embodiment and cognitive semantics

In light of the phenomenological insights discussed above, this section focuses on examining how the theories from embodied cognition and cognitive semantics influence research in HCI and design, thereby aiming to inform the exploration of an approach to ambient media design.

2.3.2.1 Embodied cognition

Embodied cognition emerged in the late 20th century from the critique that classical cognitive science dedicates little attention to the body's role in the human mind. Countering this, embodied cognition believes that cognitive processes are largely shaped by the body's states. The *Embodied Mind* (Varela et al., 1991) is widely acknowledged as a landmark publication in embodied cognition. Inheriting the phenomenological ideas of Merleau-Ponty, Varela et al. (1991) reject the traditional view of cognition as internal mental representations and develop an enactive approach (a radical version of embodied cognition) to cognitive science (Dawson, 2013, p. 11; Wilson & Foglia, 2015). They argue that cognition is shaped by the sensory-motor interaction between the acting human and the environment: "By using the term embodied we mean to highlight two points: first that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological and cultural context" (Varela et al., 1991, pp. 172-173). Dawson (2013, p. 222) also uses the term "sense-act mechanism" to denote the tight relationship between perception and action in embodied cognition.

Shapiro (2010) systematically examines various types of research in order to develop key themes of embodied cognition and clarify the relationship between embodied cognition and classical cognitive science. He indicates that embodied cognition arises from a variety of research areas (e.g., philosophy and psychology) and that it still lacks rigidly defined theories and uniform commitments to several fundamental issues. He attempts to provide a clarification of these problems by presenting three general hypotheses on embodied cognition: conceptualization, replacement, and constitution. The conceptualization hypothesis claims that the conceptual system people use to make sense of the world is determined and constrained by the body's properties. This theme focuses on analyzing conceptual issues regarding the

role of metaphor in cognition (Lakoff & Johnson, 1980) and organisms' vision (Varela et al., 1991). Shapiro also argues that Lakoff and Johnson's views on criticizing standard cognitive science are too narrow, as they mainly rely on symbolic representation, which has less of a bodily basis. Replacement means that humans' bodily interaction with the world can replace the role of representational processing that is emphasized in classical cognitive science. Shapiro proposes the third theme, constitution, to denote that the body and the environment, as two indispensable elements, jointly influence cognition. Overall, as mentioned by Dawson (2013, p. 262), Shapiro's first two hypotheses are formulated from the perspective of radical embodied cognitive science, which studies human cognition in the rich and mutual relationships between mind, body, and world. These themes, which echo Merleau-Ponty's existential phenomenology, offer insightful views for further research on embodied approaches to ambient media design.

2.3.2.2 Cognitive linguistics and its influence in design

As a modern research field, cognitive linguistics is firmly rooted in the early development of cognitive science and arises from the assumption that linguistic and cognitive processes cannot be separated. Cognitive linguists believe that language provides a lens through which to investigate cognitive phenomena and functions, as language is regarded as a window that reflects the underlying mechanisms of the human mind (Evans & Green, 2006; Hurtienne, 2017; Lakoff, 2012). Cognitive semantics is a main subfield of cognitive linguistics that is concerned with the relationship between conceptual structure (the pattern of meaning creation) and embodied experience. A key principle of cognitive semantics is that conceptual structure directly arises from everyday bodily experience (linguistic meaning is embodied in nature), and Lakoff (1987, p. xiv) argues that the human conceptual system is rooted in the perceptual and motor experience with both physical and social environments. In a word, embodiment is the central

idea in cognitive linguistics, which is fundamentally concerned with the relationship between language, cognition, and human bodily experience with the environment.

A growing amount of research shows that the insights from cognitive linguistics (Evans & Green, 2006; Gibbs, 2005, 2006; Johnson, 1987; Lakoff, 2008; Lakoff & Johnson, 1980, 1999) can contribute to HCI (Bakker et al., 2012; Hurtienne, 2017; Hurtienne & Israel, 2007; Madsen, 1994), product design (Van Rompay et al., 2005), and interactive media (Antle et al., 2009, 2011; Chow, 2013). Conceptual metaphor and image schemas are two influential and central concepts in cognitive linguistics (Johnson, 1987; Lakoff, 1987; Lakoff & Johnson, 1980). The basic idea of these two cognitive-semantic notions is that bodily experience forms the basis of metaphor and expression, and that abstract meanings can be understood in terms of concrete experiences derived from everyday perception, action, and spatial relations.

Image schemas, termed by Johnson (1987), are a range of fundamental patterns (also called cogs or cognitive primitives [Lakoff, 2012]) arising from human's repeated perceptual and motor experience, which organize people's everyday meaning expression and experience in a general and abstract way (Johnson, 1987, p. 29, p. 79). To emphasize the embodied nature of image schemas, Johnson also calls them "embodied schemas," thereby indicating that they are derived from bodily experiences with objects and environments (pp. 19–23). Image schemas are highly abstract patterns, as opposed to the specific and concrete mental images described above, but can make people's experience meaningful by extending to metaphorical concepts. The second central concept in cognitive linguistics is conceptual metaphor (Lakoff, 1992; Lakoff & Johnson, 1980), which refers to pervasive phenomena in everyday conventional language that many expressions are understood with a metaphorical mapping. The metaphorical mapping of conceptual metaphors

is constructed and inherently arises from embodied experience, enabling people to understand a relatively abstract meaning (concept) in terms of another embodied concrete experience (phenomenon). As most conceptual metaphors are grounded in perceptual-motor experience (embodied schemas), some researchers use the term “embodied metaphor” (e.g., Antle et al., 2009; Van Rompay & Hekkert, 2001). Embodied metaphors are the concrete applications and metaphorical extensions of an embodied schema. For example, the concept “container schema” regards the structure of inner, outer, and boundary spaces (Lakoff & Johnson, 1980). Van Rompay and Hekkert (2001) draw on this schema to explore the bodily experience of safety by conducting an experiment evaluating the design of three bus stops. The bus stop as a shelter can be viewed as an embodied metaphor that conveys the spatial meaning of inside and outside, which also comprises the understanding of security in product design. Dourish (2001) also mentions that using spatial metaphors is a fundamental form of social interaction, especially in collaborative work systems. Metaphors are not limited to the linguistic field, and other perceptual elements (i.e., visual forms and bodily actions) can also be regarded as metaphors in design research.

Madsen (1994) presents a metaphorical design approach to computer interface design based on his research on interface metaphors (Carroll et al., 1988). He analyzes five cases related to the use of metaphors in various scenarios (e.g., the use of computers in a library), based on which, he formulates a range of methodological guidelines for developing designs by using metaphorical thinking (e.g., finding metaphors in verbal reports described by users). Finally, he summarizes numerous characteristics of the role of metaphor in the context of design (e.g., a metaphor helping users to more easily understand a system model). Compared with the study on the metaphorical meaning of bus stops (Van Rompay & Hekkert, 2001), metaphorical design focuses on how the theory of conceptual metaphor

informs computer interface design, rather than on the embodied grounding and spatial features of metaphor. Madsen's research approach to metaphorical design offers inspiring guidance for the research design of the current project.

2.3.2.3 Embodied metaphor and embodied schema

In view of the concern with embodiment in this research, the purpose of this section is to clarify two terms: embodied metaphor and embodied schema. First, it is necessary to delineate the relationship between conceptual metaphor, embodied metaphor, and visual metaphor. Conceptual metaphor describes a concrete conceptual idea (source domain) that is used to express a relatively abstract conceptual idea (target domain) (Lakoff & Johnson, 1980, pp. 108-109). In the conceptual metaphor "life is a journey," the concept of a journey, which describes a process from beginning to end, is mapped onto a relatively abstract concept, namely "life," which is less directly related to bodily interactions in or with the environment. Embodied metaphors are conceptual metaphors with a clear grounding in specific bodily experiences (van Rompay, 2005), in which the source domain is extended from the schema that are tightly connected to bodily experiences (Bakker et al., 2012). Some researchers also use "embodied conceptual metaphor" (e.g., Flusberg et al., 2010) to emphasize the embodied grounding of conceptual metaphor. For example, a chair is described as stable (balanced), which is extended from the embodied schema "balance" that is generated from the idea of balance in bodily experiences, such as walking or holding a bowl of water. The bodily experiences of balance (source domain) are used to describe the abstract meaning of a design's form (target domain). Third, visual (image) metaphor is the mapping between visually similar images (Lakoff, 1987). In the example "The woman's waist is an hourglass," the shape of the waist is said to be similar to the shape of hourglass, which is not conceptual mapping but rather an expression of the similarity between two mental images. Like embodied

metaphor, image mapping also originates from bodily perceptions and experience about the world. Van Rompay (2005) proposes that “resemblance metaphor” depends on a resemblance between two objects (e.g., a chair is designed like a flower), which is basically the same as image metaphor.

Based on these three types of metaphor, this research suggests that embodied metaphors include partial conceptual metaphors, while visual metaphors emphasize the mapping of visual similarity (Figure 2.4). Visual mapping and embodied metaphorical mapping (embodied mapping) both adhere to the fundamental principles of the image-schematic structure. As the RQ of this research is how embodied metaphors in ambient media mediate audience experiences and facilitate meaningful interactions, the case studies below demonstrate how embodied and visual mapping generate various meanings.

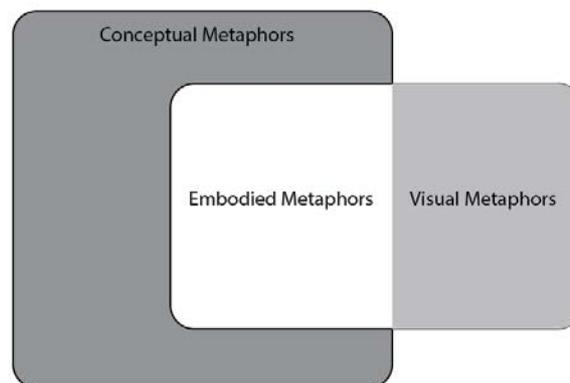


Figure 2.4 Conceptual metaphor, visual metaphor, and embodied metaphor

Another central concept is embodied schema. People’s understanding of concepts is structured by a series of recurring patterns (schematic structures) originating from long-term bodily experiences with the world. As mentioned in the previous section, Johnson (1987, p. 127) summarizes a range of image schemas, such as container, balance, path, link, scale, part-whole, full-empty, and center-periphery, which pervasively structure people’s understanding

and expression in everyday experience. Johnson notes that “embodied schema” and “image schema” can be used interchangeably (p. 23), noting that the term “embodied schema” emphasizes that these schematic structures are grounded in the bodily interaction with physical spaces and objects.

To clarify the relationship between embodied metaphor, embodied schema, and bodily experience, an example of size (scale) schema is depicted as a diagram (Figure 2.5), which shows how an embodied schema emerges and structures people’s understanding and their sharing of meanings (the diagram is drawn based on Antle et al. [2009]).

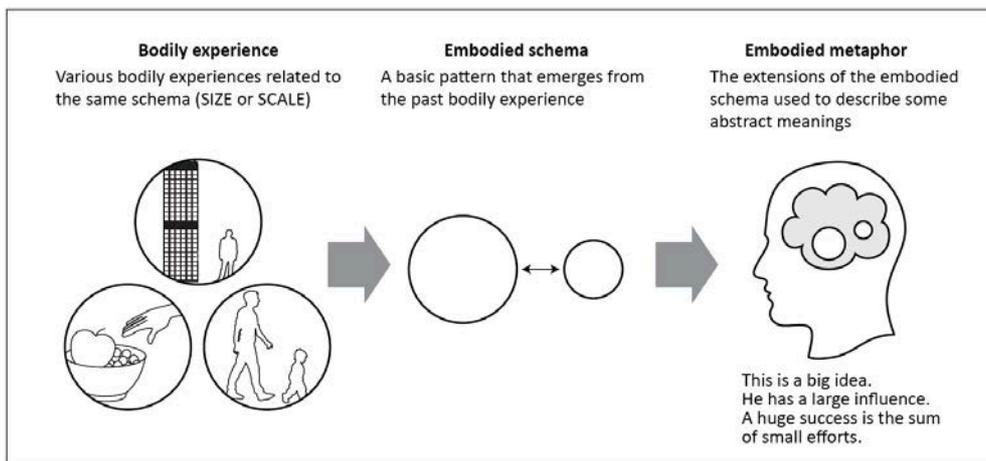


Figure 2.5 Embodied metaphor and embodied schema

In the process of growing up, people have various bodily interactions with everyday objects and environments: they pick up fruits with different sizes and perceive the size difference between an adult and a child, or a building and a person. These experiences follow a recurrent pattern regarding size differences, which forms the embodied schema (size). This schema can be extended as a range of metaphors that help people express and understand meanings. For example, in the sentence “A huge success is the sum of small efforts,” success and effort are relatively abstract words, and “huge” and “small” are used to concretize them in terms of the schema (size) generated

by the experience with physical objects. Antle et al. (2009) investigate how embodied schemas can be used to support imagination in interactive audio-based environments. They take balance schema as an example and believe that early bodily experiences (i.e., learning to walk and keeping balance on a teeter-totter) help to form the balance schema that can be applied to understand more abstract ideas (e.g., “He needs emotional balance,” “This plan can balance the contradiction between two countries”). Bakker et al. (2012) design a tangible interaction system to explore how embodied metaphors can facilitate children’s learning of abstract concepts. The container schema is described as a pattern concerning inside and outside, and is pervasively grounded in people’s bodily experiences. Metaphors such as “Their relationship is in crisis” and “The situation is out of control” are the extensions of the balance schema.

In addition, the terms “metaphorical concept” (MC) and “metaphorical expression” (ME) are used in this model (Figure 2.6) to elaborate how meanings can be understood through metaphor-based mappings. According to Lakoff and Johnson (1980, pp. 6-7), a metaphorical concept is a metaphor such as “Life is a journey,” and can also be viewed as a metaphorical extension of an embodied (image) schema, as human’s thinking is metaphorically conceptualized. Moreover, MEs are tightly and systematically bound to MCs, and ME in this research context also refers to those specific bodily actions that are more concrete and specific than MCs. For example, a physical affordance may trigger a bodily action that is in accordance with the familiarity of bodily skills, while in the meantime the action can be an ME signifying an MC based on a certain embodied schema.

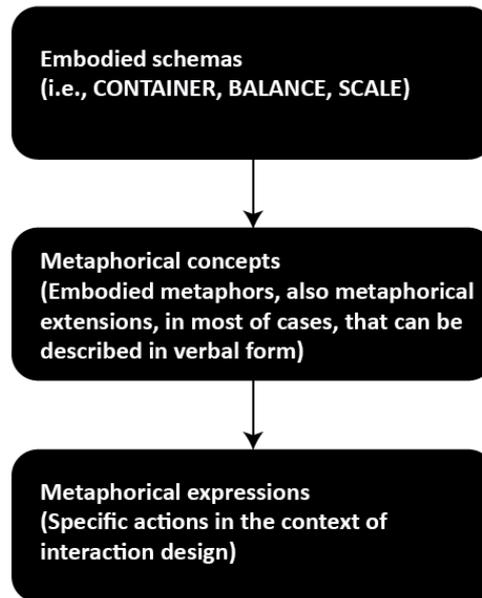


Figure 2.6 Metaphorical concepts and metaphorical expressions

2.3.3 The relevance of affordances to embodiment

Having reviewed the theories on embodied cognition and cognitive linguistics, this section aims to clarify the concept of “affordances” and its relevance to embodiment and ambient media.

The property of spatiality (see 2.2.4.1) indicates that the possibility of interaction with ambient media is closely related to the physical and spatial features of public space. Since Norman (1988) brought the concept of affordances to product design in his book *The Design of Everyday Things*, the notion of “affordances” has been extensively applied to and developed in the interaction design domain. According to Gibson’s earlier thoughts on the concept (1979), the term “affordances” refers to the relations between the physical appearance of an environment or object and the potential actions of organisms that are supported by it. From a phenomenological perspective, the characteristics of the environment potentially invite human actions, and people act unreflectively with needs of surrounding objects and features (Dreyfus and Kelly, 2007). Although Gibson does not state that “affordances”

originate from phenomenological theories, the underlying connections between affordances and embodiment have been frequently discussed (Dreyfus, 1996; Dourish, 2001; Heft, 1989; Kaptelinin, 2014; Rietveld, 2012; Withagen et al., 2012). For example, Heft (1989) states that “Both Merleau-Ponty and Gibson emphasize that perceiving simultaneously entails an awareness of both the environment and the body” and Dreyfus (1996) states that “J.J. Gibson, like Merleau-Ponty, sees that characteristics of the human world . . . are correlative with our bodily capacities and acquired skills.”

In his discussion of the commonality between affordances and Merleau-Ponty’s phenomenology of perception, Heft (1989) considers that the characteristics of affordances relate to humans’ body scaling. For example, the affordances that a chair offers the possibility of sitting or a glass of water affords the possibility of drinking are dependent on humans’ bodily conditions (a chair may not offer the possibility of sitting for a child). The concepts of intentional arc and affordances share many features and meanings. Merleau-Ponty’s intentional arc represents the interrelation of skillful action and perception (Dreyfus, 1996), which also reflects the potentials of action in affordances. Dreyfus (1996) extends the concept by proposing that the capability of perceiving an affordance is determined by both bodily experience and cultural habits (skills). Both intentional arc and affordances highlight that perception involves an awareness of both the environment and the body, and that the action is generated from a mutual relationship between the body and its surroundings (Heft, 1989).

In the context of design research, an affordance is the perceptual relationship between a user and an artifact (or installation) that determines which behavior may possibly take place. For example, a door handle reminds a user to open the door in a right (or wrong) way. Hartson (2003) expands the concept by proposing four types of affordances: cognitive, physical, sensory,

and functional affordances. The idea of cognitive affordance lies closest to Norman's definition of affordance, which refers to the perceived clues of the product that indicate how the user should use it. Cognitive affordance is the design characteristic that can help users think about and understand the meaning or function of acting with an artifact or interactive system. For example, a symbol indicates that a button can be pressed to play a song and a ball-like door handle indicates it can be grasped and turned. Physical affordance refers to the actual and physical features of an artifact that can support people in performing actions. A ball-like handle looks like it can be physically turned but is actually designed for pushing rather than turning. Sensory affordance concerns the properties of a product that offer possibilities for perceiving sensory information (visual, tactile, and auditory sensations). Functional affordance is a holistic design property that can help users to appropriately and effectively complete functional tasks through a series of actions and to a certain extent concerns the internal functional capability of an interactive system. Morie et al. (2005) propose the term "emotional affordance" as a complementary concept to Hartson's theory in order to emphasize design features that can give rise to an emotional response. Affordance is a crucial design concern in designing quality and embodied experience in interactive design. From the perspective of experience, the different types of affordance tightly correspond to the components of audience experiences. Based on the close relationship between affordances, embodiment, and experience, the review of this section is expected to inform further studies on analyzing and designing embodied interactions with ambient media.

2.3.4 Embodied approaches in HCI

Embodied thinking provides HCI research with valuable insights for understanding user experience and designing interactive systems. This

section reviews relevant studies and approaches in HCI to obtain references for the present research.

In *Where the Action Is: The Foundations of Embodied Interaction*, Paul Dourish (2001) coins the term “embodied interaction” to describe a new perspective in HCI research that emphasizes the tangible and social habits of people’s interaction with digital technology. Dourish draws upon phenomenological ideas from Heidegger and Merleau-Ponty as the theoretical underpinnings for his analysis on the embodied nature of HCI. He considers that people increasingly face computation that moves beyond the traditional spaces of the desk and integrates itself into people’s living experience in the physical and social environment, and that embodied interaction is comprised of both tangible and social interaction. Dourish defines embodiment as the property of people’s engagement with the world from which meanings are generated. This entails not only physical interaction but also interaction that is situated in daily activities; interaction is an embodied phenomenon that occurs in physical and social settings. There are three reasons why embodiment is relevant for the interaction between humans and computers (machines). The first is that interaction is physically situated and embodied in the environment in which it arises, whereby the environment, including the physical and social environment, plays an essential role in activating and modulating interaction. The second is that the methods adopted in user studies (e.g., observations and interview) in HCI are used to understand embodied experience in concrete and real settings, with real artifacts and actual people. Third, artifacts embody various roles in everyday interaction. A medical record card is not only a tool presenting the information of a patient but also a medium embodying a range of activities around the patient. For instance, handwriting on the card exhibits information about the different people who perform specific duties in the treatment process, and the worn paper indicates a condition of being frequently used.

In sum, from a phenomenological perspective, embodiment is defined as the foundation of interaction, and “embodied interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artifacts” (Dourish, 2001). It is grounded in the ways in which humans interact with the world. Physical interaction is a trend aiming to return digital computing to the real environment and design intelligent spaces and products that communicate with us and react to our actions. It aims to discover our bodily and spatial skills and embed interaction in natural activities. On the other hand, a social environment arises from the collective and coordinated action of a group of people, thereby incorporating actions in spaces and technologies. The insights of embodied interaction have inspired many HCI studies (e.g., Erve et al., 2011; Hornecker & Buur, 2006; Larssen et al., 2006; Svanæs, 2013). Erve et al. (2011) apply the principles of embodied interaction to design interactive artifacts for enhancing people’s everyday remembering processes. Three of their design experiments show that embodied interaction is an insightful approach in designing for storing, recalling, and enhancing everyday memories. Hornecker and Buur (2006) develop a framework to analyze social experience in tangible interactions by discussing a series of themes, such as spatial interaction and embodied facilitation, which extend Dourish’s theories. Based on Dourish’s thoughts, kinesthetic sense modality is regarded as an important dimension and a source of designing interaction (Larssen et al., 2006; Svanæs, 2013). However, Svanæs (2013) also indicates that Dourish places surprisingly little emphasis on the body’s role and adopts rather a broader perspective on both physical and social interactions. As Dourish states, “Indeed, the lessons I want to draw from the phenomenological perspective will be broader (and less specific) than those that primarily occupied Merleau-Ponty” (2001, p. 115).

Loke and Robertson (2013) present a methodology called “moving and making strange” for designing movement-based interactions. Through a series of empirical design works, they develop a set of design principles and toolkits to design and evaluate movement-based interactions, whereby the methodology recognizes that body movement takes center stage in cognition. Based on embodied cognition, a design framework describes four types of embodied design thinking: anthropomorphizing the body’s characteristics, image-schematic thinking about design, sensory attributes for meaning expression, and bodily movements in interacting with products (Van Rompay & Ludden, 2015). Despite the focus on product design, this framework is very much in line with the theoretical basis of this research in regard to embodiment and meaningful experience. Hurtienne and Israel (2007) develop a continuum comprising four levels of knowledge in intuitive interaction, suggesting that the level of sensorimotor knowledge is most relevant to the ideas of embodied cognition, such as image schemas and affordances. This classification can be compared to Dreyfus’ five stages of acquiring skills, and “intuitivity” in interaction is inherently in line with the idea of “intentionality without representation.” As Dreyfus (1996) states: “Such skillful coping does not require a mental representation of its goal.” Based on the continuum and Johnson’s work on image schemas (1987), a design approach to bridging physical manipulation and meaningful experience is also proposed.

Building on embodied interaction, Millard and Soylu (2009) introduce an embodied approach to designing interaction in pervasive computing environments by focusing on tangible and multi-modal interaction. Based on ludic design, Nam and Kim (2011) develop a design methodology called “design by tangible stories” for the design of interactive products, which aims to transform everyday artifacts into interactive artifacts for enhancing ludic experience. The methodology comprises three many features: making imaginary meaning, allowing unexpected discovery, and incorporating

tangible computing into ludic value. This approach features narrative making through tangible interaction. These approaches apply the theory of embodiment within more specific interaction design contexts and provide valuable references for the current study. A more recent work (Hornecker et al., 2017) presents three differentiations for delineating different approaches in embodied interaction research: subjective vs. objective perspective, body vs. context, and practice vs. cognitive structure. This provides a clear guidance for identifying approaches to embodied interaction.

These studies all dedicate special attention to how meaningful experience is elicited from the tangible interaction between the body and physical products or spaces. In the context of experience with ambient media, the main objective of this research is to propose an embodied approach to the design of ambient media toward facilitating meaningful experience, which is expected to be evaluated through empirical study and design experiments.

In brief, after the above review on embodied cognition, cognitive linguistics, and embodied interaction, this research believes that cognition, language, and meaning are grounded in the perceptual and motor experience with the world. This understanding not only forms a fundamental basis for embodied cognitive science but also lays an important theoretical foundation for HCI and design research.

2.4 Participating audience experiences

As the major goal of developing an embodied approach is to facilitate people's meaningful experience through designing embodied interactions with ambient media, this section aims to delineate a position for the concept of experience in regard to embodiment and ambient media. As the focus of design paradigms increasingly transits from creating artifacts with practical functions to designing for experience, a large amount of studies are

concerned with user experience (Hassenzahl et al., 2010; Pucillo & Cascini, 2014; Redström, 2006), product experience (Desmet & Hekkert, 2007), brand experience (Brakus et al., 2009; Hulten, 2011), and audience experience (Bilda et al., 2006; Kilpatrick, 2010; Pitts, 2010). These experience-focused studies dedicate attention to the emotional, meaningful, and hedonic qualities of experiences with products or services, rather than to utility or usability.

In order to identify a specific scope of audience experiences in terms of ambient media design, this section first reviews concepts regarding experience from various fields, after which it attempts to articulate the relations between experience with ambient media and other experience-related concepts. The underlying connections between these ideas and key factors are identified to provide a holistic and useful understanding in view of constructing a theoretical framework.

2.4.1 Phenomenological concepts of experience

As the previous section shows, the focus of phenomenology is to study how people experience the world from a first-person perspective. The central idea of experience is intentionality, whereby an experience is considered as mental content directed toward an object or phenomenon, and sensory contents such as color and material are experienced in various ways (Husserl, 2012, p. 170). Preliminary experience entails physically perceiving something through bodily perception, while humans also have inner perceptions that reflect a self-state of consciousness (Husserl, 2012, p. 9). Based on Husserl's insights, his followers develop different theoretical understandings, for instance through the notions of Being-in-the-world (Heidegger, 1962) and intentional arc (Merleau-Ponty, 1962). Heidegger relates experience to daily human life, such as a carpenter's use of a hammer, while Merleau-Ponty stresses the phenomenological analysis of the process of perception by considering perception as an active interaction involving a human's motivations, bodily

actions, and sensory feelings (Svanæs, 2000, p. 12). This means that perception is a core process in experiences as it bridges situated physical environments, the human body, bodily skills, and bodily actions.

Embodied mind and embodied metaphor provide a wider perspective for understanding human experience (Lakoff & Johnson, 1980, 1999). For example, a color is not an objective concept but a human's subjective experience, which is generated by a combination of optical settings, personal interests, and bodily inner structures. In line with Merleau-Ponty's insights on perception, the experience of color depends on the relations between the physiological organs of a body, subjective intentions, and the physical conditions of lighting: "an embodied realism" (Lakoff & Johnson, 1999, p26). This means that human experience in the world is subjectively "real" and highly affected by the cultural, emotional, and bodily aspects of a perceiver. For instance, the sky's color is perceived as blue, which is a visual experience formed by light scattering and sensory systems in the body, while the sky in itself does not have color without light. To a certain extent, perceptual experiences are to considerable degree formed by embodied communications involving both the physical world and bodily conditions.

As discussed in section 2.3, phenomenology is a philosophical branch that focuses on studying the structure of human experience. It is widely adopted in design research, in which a range of terms regarding experience are currently emerging, such as user experience, product experience, service experience, consumer experience, and experience design. This research is concerned with whether audiences experience can be facilitated by embodied interactions with ambient media. Therefore, the main objective of this section is to derive the underlying attributes of experience that are interrelated to ambient media and embodiment. In this regard, the following section reviews several key concepts of experience from different fields of

research and subsequently compares them to reveal a specific conceptualization of audience experiences within the context of this research.

2.4.2 User experience

Desmet (2002, p. 110) proposes a conceptual model for studying the emotional experience of a product, which comprises three variables that contribute to evoking emotional responses. The core meaning of this model is embodied in the user's appraisal of the relationship between product-related stimuli and his/her concerns. If the design of a product can successfully fulfill people's potential expectations, goals, and needs during their interaction with the product, this results in an immediate positive appraisal that eventually generates positive emotions. On the contrary, an immediate evaluation (appraisal) that conflicts with the user's concerns leads to negative emotions.

According to Hekkert (2006), product experience entails a unity of effects generated from user-product interaction, which comprises aesthetic experience, experience of meaning, and emotional experience. He also believes that an emotion is evoked by the appraisal of whether a product can beneficially or harmfully meet a user's desires in a certain situation. Based on these definitions, Desmet and Hekkert (2007) develop a framework comprising three types of experience (Figure 2.7). Aesthetic experience is in accordance with the notion of "sense" in Schmitt's (1999) consumer experience theory and Norman's (2005, p. 22) visceral level experience. In the latter, the perception of the physical attributes of products and tactile senses result in aesthetic experience, while the experience of meaning mainly refers to a user's cognitive processing, which involves the memory of past experiences (familiarity and cultural skills) and metaphorical and symbolic interpretation. For example, many icons and buttons are used to represent various functions in screen-based interfaces. For instance, an icon with a large

“O” shape stands for launching the software of Microsoft Outlook, as “O” is an abbreviation of “Outlook.” The appraisal of experience with meaning largely depends on a user’s personal knowledge and cultural background, which can determine how cognition processing interprets such a symbol. The aesthetic experience and experience of meaning both contribute to emotional experience, which is linked to the basic model of emotion.

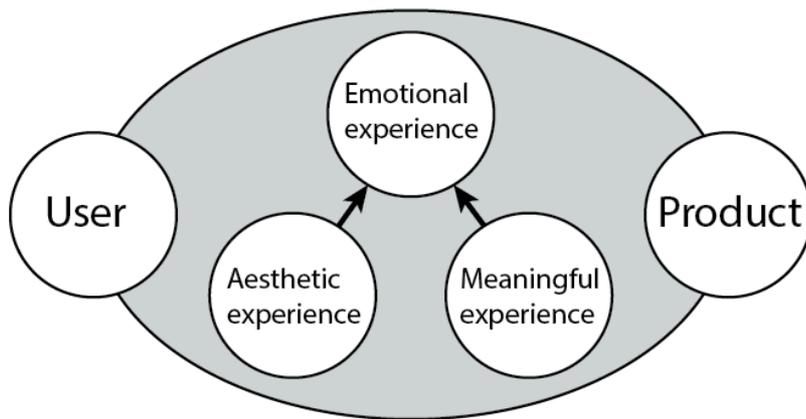


Figure 2.7 Framework of product experience (adapted from Desmet & Hekkert, 2007)

Norman (2005, p. 22) articulates a three-layer model (Figure 2.8) to help designers understand users’ emotional experience. This model represents experience at the visceral, behavioral, and reflective levels, similarly to Schmitt’s model, although Desmet focuses more strongly on product experience, while Schmitt is rather concerned with marketing and branding. At the visceral level, a user experiences a product by perceiving its physical features (color, material, and shape), which is associated with the innate structure of the human body as an aspect of embodiment. These innate sensory experiences are biologically stimulated by the outer physical appearance of a product. This layer of visceral experience is basically similar to the sensory experience in Schmitt’s five-type model. Experience at the behavioral level concerns how effectively and efficiently users interact with a

product by “skillful coping” (Dreyfus, 1996), in which skills are acquired through routine practices and activities (past experience). Positive or negative experiences can be elicited when people intuitively interact with a product, depending on whether the product’s design product can meet the user’s expectation and bodily skills. For example, if a door can easily be opened or closed without any instructions, this may result in a successful experience at the behavioral level. Reflective experience represents the highest level in this model, whereby consciousness, evaluation, and emotions are generated based on the previous levels. This level comprises the mental internalization of external sensations and actions that transform into emotions and the cognitive appraisal of experience: a process that is affected not only by immediate experiences (perceptions and bodily actions) but also by social or cultural skills (Dreyfus, 1996) that vary with temporal-spatial factors.

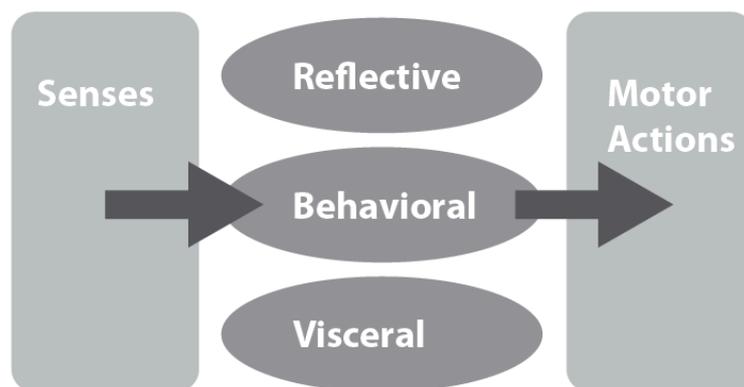


Figure 2.8 Three layers of experiences (adapted from Norman, 2005)

Von Saucken and Gomez (2014) establish a unified-experience framework for supporting the analysis of user experience by reviewing many major theories of experience from various design disciplines. Compared with previous models, this model integrates a number of variables concerning the temporal factors of interaction processes, whereby user experience is comprised of three phases: before, during, and after interacting. In the first phase, one has particular needs, motives, and desires in a certain situation, which is in line

with the notion of “concern” in Desmet’s model and with the “goals and intention of action” in the action cycle illustrated by Norman (2013, p. 55). The second phase regards the physical or bodily interaction with a product, in which the process of action-perception and input-output is basically similar to Norman’s action model, which presents how the human body interacts with a product or environment involving bodily skills and sensory perceptions. This is in accordance with Desmet’s “aesthetic experience.” As illustrated in the cycle, user experience is formed by evaluating and reflecting on the overall interaction in terms of one’s personal background and familiarity with settings. This model is defined with personal experience and social experience as two modes that correspond to the tangible interaction and social interaction described by Dourish (1999) in the framework of embodied interaction. Although this unified model mainly focuses on product experience, it includes brand (associated values) as one element in the “Macro UX Context,” which means that the appraisal of product experience and brand experience are interrelated.

2.4.3 Brand experience

Schmitt (1999) establishes a framework (SEMS) for studying experiential marketing and consumer experience, proposing five categories of experience: sensing, feeling, thinking, acting, and relating. He claims that sensory experiences are generated through a human’s sensory system, including vision, audition, touch, smell, and taste, and that sensory experiences in branding and marketing have a significant impact on establishing the identity of corporations and brands. Brand impression or identity can be evoked by sensory stimuli such as visual elements (color, graphics, and light), audio elements (tone, frequency, loudness, and rhythm), tactile elements (material and texture) and other sensory factors. Law et al. (2009) claim that brand experience has a broader meaning than user experience, arguing that the former includes not only experiences of branded products but also interaction

with a particular company and the products and services it provides. Brand experience and user experience affect each other. In other words, brand experience shares many elements with user experience, as a tangible product can physically embody the personality and value of a brand through consumer-product interaction (Lee & Kang, 2012). A framework for brand-specific design proposes that tangible or sensory attributes in products can evoke a corresponding brand personality or awareness for consumers (Karjalainen, 2003). Nokia's mobile phone design is a typical example of a brand-specific design that applies a physical design pattern (the curves and layout of the keyboard) to different phone models, which provides consumers with a consistent and specific visual experience. Furthermore, experiential marketing suggests that the design of sensory experience also is a strategic approach to differentiating products and brands, motivating consumers, and providing value. The major objective of experience design is to draw on sensory stimuli to create distinctive brand identities and provide consumers with aesthetic pleasure and satisfaction, which contribute to impressive experiences (Schmitt, 1999).

The second type in Schmitt's framework regards feeling experiences, including moods and emotions, which are linked to emotional experiences evoked by the instant appraisal of needs and products (Desmet, 2002), though Schmitt's concept is more closely related to consumption experience than to product experience. Furthermore, interactions with products or services can potentially contribute to sculpting a brand's personality and image by creating the user's emotional experience (von Saucken & Gomez, 2014). In addition, Jordan (2000) classifies four types of pleasure, in which the "ideo-pleasure" experience is embodied through a product's tangible forms (e.g., sustainable material) and brand image.

To “think” in this model means to create a cognitive experience by engaging consumers in active thinking and triggering surprise, imagination, curiosity, and something that differs from commonly expected needs. The act of experience is targeted to facilitate physical actions and experiences by eliciting consumers’ embodied interaction with marketing-related stimuli such as tangible products, ambient media, and environments. To a large extent, certain characteristics of the act of experience correspond to a number of concepts discussed in the previous sections, such as bodily intentionality (Rietveld, 2012), the behavioral level of experience (Norman, 2005), affordances (Gibson, 1979), and ambient media (Jurca, 2012). The “relate” experience in marketing research extends to personal sensing, feeling, thinking, and behavior, as it connects people’s experience to social and cultural meanings that are embodied in branding. In a sense, these five types of consumer experience are aligned with the experience models of Norman (2005), Jordan (2000), Desmet and Hekkert (2007), and Hartson (2003).

Schmitt (2009) believes that the major function of branding is to produce consumer experiences and that the concept of brand experience in marketing research more closely approaches the core of branding than other brand concepts such as brand value, brand attitude, brand attachment, and brand personality. Consumers expect lively and authentic experiences rather than abstract brand information such as slogans and descriptions with a high cognitive load. Those who treat a brand as a mere identity or image miss many opportunities for designing brand experience.

Following Schmitt’s theory of experiential marketing, Brakus et al. (2009) conceptualize brand experience as sensory, emotional, cognitive, and behavioral consumer responses stimulated by brand-related media (graphics, products or services, and settings). In other words, from the perspective of embodiment, brand experience is generated from situated engagement and

embodied interaction between consumers and brand-related stimuli, rather than from rational evaluations of or attitudes toward a brand. In accordance with this conceptualization of brand experience, a spectrum of brand experience is revealed: sensory, affective, intellectual, and behavioral. The definition proposed by Brakus et al. (2009) has been widely adopted by academics and practitioners. There are 1,193 citation counts for this paper, according to Google Scholar. For example, Moller and Herm (2013) investigate how sensory experiences affect how brand personality is perceived by consumers. Through an experiment conducted in an actual setting and a laboratory experiment, they found that the changes in physical environments (the hardness of the furniture) that were perceived by the participants' visual and tactile senses resulted in sensory consumer experiences. These bodily experiences contribute to various perceptions of brand personality and metaphorically deliver meaning to consumers' intellectual experience (brand cognition and imagination). In a recent study, Khana and Rahmanb (2015) draw upon a content-analysis approach to screen and examine over 70 papers relevant to brand experience, which they classify as either empirical or conceptual. They present a conceptual model comprising independent and dependent variables regarding brand experience, which enables researchers to better understand the position of brand experience and identify branding strategies.

Hulten (2009) proposes a model of sensory marketing that emphasizes the impact of sensory experience on consumers' perception of brand personality and brand imagery. A sensory strategy model is formulated by integrating the five human senses, sensory stimuli (objects, lights, materials, and sound), and brand-related information, which constitute a multi-sensory flow. These sensory stimuli, serving as the media of information transfer, are intended to engage consumers in multi-sensory experiences, which also evoke emotional and cognitive experience by transferring brand value and brand image. From

the perspective of experiential marketing, this model of sensory strategies is actually aligned to the concept of “sensory marketing” in the five attributes framework (Schmitt, 1999) and to the sensory dimension of brand experience (Brakus et al., 2009).

2.4.4 Audience experience

In the field of interactive or new media art, audiences usually refer to people who participate in or are engaged in interactions with art works. Bilda et al. (2006) investigate audience experiences with interactive art works through a protocol analysis of three experiments. They propose a framework of audience experiences with three components: body, thought, and feedback, which are congruent with Norman’s three levels of experience and play different roles in audience experiences. The software INTERACT is used as a tool in analyzing video data recorded from three experiments examining real-time interactive art experiences. This empirical study shows that the body mediates both feedback (perception) and thought (cognition). The body receives multi-sensory signals from the feedback of art works and activates interactive effects by performing bodily actions, which constitute the basis of thinking (cognition) and emotion. In their subsequent research, a model of audience experiences is proposed as a means of evaluating interactive art installations in terms of the temporal dimension of interaction (Bilda et al., 2008). Through empirical studies, this model identifies four major interaction phases: adaptation, learning, anticipation, and deeper understanding. A comparison between this experience model and others is presented in section 2.3.5.

Walmsley and Franks (2011) discuss the role of audience experience in public art activities and entertainment. Similarly to the two types of engagement (see 2.1.4), they distinguish between active and passive participants. Active participants are those who proactively participate in art activities on their

own initiative. For example, local residents take part in various art forms in a community art show. Passive participation refers to audiences who intend to spectate rather than directly join activities. In line with Schmitt's experiential marketing, two case studies of art festivals indicate that audience experiences are elicited on several levels: tangible, emotional, social, and intellectual. The organizer should place the audience center stage in art activities by creating memorable and co-created experiences involving two-way interactions between creative teams (artists or designers) and audiences, art works, and participants.

Audience experiences are explored in ambient media from the perspective of the experience economy (Semenescu & Martinsson, 2012). The major strategy of branding in the experience economy is not to advertise products or services but to enable audiences to have a unique experience. Several shifts are currently emerging in the field of marketing: from verbal information to multi-sensory experience, from two-dimensional media to spatial (ambient) media, and from one-way transmission to dynamic engagement. These shifts manifest that the focus of ambient media design is to evoke audiences' potential imagination, emotion, and thinking in alternative ways, which can diminish their resistance toward advertising. Happiness and fun are considered to be important factors in audience experiences. If a designed ambient media work can evoke happy feelings and curiosity, audiences immediately feel the need to be "involved" in it.

Heeter (2000) investigates designed audience experience in interactive video systems by analyzing a range of interactivity variables. A designed audience experience is one in which people participate in an event within a certain temporal-spatial context that is structured by designers. The process of creating a designed experience is an exploration of how to impact, engage, and empower audiences. As the designer's goal may or may not entirely

match the audience's expectation, this depends on the affordances that to what extent can be perceived and achieved by the audience. Heeter also emphasizes that embodied being has a crucial impact on audience-media interaction and that humans' being is embodied in their interaction with the physical world and themselves (cognition, perception, intent, thinking, feeling, imaging, and other mental activities). However, digital media usually offer audiences virtual spaces by simulating reality, rather than realistic spaces that can be physically accessed. Despite the fact that virtual spaces are not physical environments, digital media (interactive television) can elicit engaging experiences by employing audiences' innate bodily structure and skills. From the perspective of media technology, Napoli (2010) examines the evolution of audience experience and analyzes the effects of contemporary media environments on audiences. Bronner and Neijens (2006) examine audience experience by conducting comparative studies across eight media, ranging from television to the Internet.

As discussed in the previous sections, experiences emerge from various settings, and the property of an experience depends on the relationship between the subject and the environment. User experiences mainly arise in the process of interacting with (using) products, and brand experiences are generated from consumers' interaction with brand-related stimuli. As ambient media are neither usable products nor consumable services, they are studied in the context of media and interaction, whereby the "audience" is the most appropriate subject of ambient media studies.

2.4.5 Technology as experience

Based on the pragmatist philosophy of John Dewey, McCarthy and Wright (2004) propose a framework to understand the aesthetic experience in interacting with interactive systems. Pragmatism considers that knowing cannot be separated from lived experience in practice and doing, whereby

knowledge arises from a process of direct participation and is constructed from acting with tools, environments, and situations. Meaning making entails embodying what is felt and experienced in life, including the sensory and emotional qualities of interacting with things. The most prominent part in the experience with technology is its potential to give rise to surprise and imaginative moments by increasing the affordances of emotional response and interaction. This view is in line with the properties of ambient media, which actively engage people in performing (interaction) and elicit unexpected experiences by transforming everyday public space into interactive media forms. Engagement plays a central role in experience by analogizing user experience with technology to audience experience in theatre, as both are concerned with acting, engagement, and agency. Engagement is a desirable response to interacting with technology and extends people's perceptions, feelings, and thoughts. Similarly, experience with technology can be compared to experience with movies considering that audiences experience a movie in three ways: as something that brings new and unexpected experiences, emotional pleasure, and sensory excitement.

Experience with technology-mediated artifacts can be understood within a framework comprising four components of experience and six stages of sense-making. The four components are tightly interconnected: intuitive perception, emotional quality, composition, and space-time. First, intuitive perception means that people perceive and feel the artifacts and immediate situations through their five senses, which gives rise to sensory engagement and perception. For example, a smart phone with a wooden texture may directly cause a natural sensation. Second, people constantly make emotional judgments in experiencing a digital product or system. The third component is composition, which entails a holistic consideration of experience. It concerns the relationship between different contextual factors (circumstances) that need to be considered as a whole. The spatiotemporal

dimension refers to the fact that every experience occurs in a certain physical, social, or digital space and during a certain period, and that experiential qualities can affect psychological time and space. Fast bodily actions may give rise to the feeling that time quickly flies by and vice versa. Meaningful experience is derived from interaction with a particular environment. In this sense, the perceptual and spatiotemporal components of experience are closely related to the views on embodied experience concerning sensory-motor experiences with everyday things. The spatiality of ambient media can be regarded as part of the fourth experiential component of technology as experience, and interaction in particular public spaces can give rise to certain audience experiences.

The six interrelated processes involved in making experience meaningful include expectation, immediate evaluation, interpretation, reflection, appropriation, and experience sharing. 1) *Expectation*: in various stages of their experience with technology, people anticipate something that will possibly happen and is related to their prior experience (e.g., expecting to download a movie from a video website). 2) *Immediate evaluation*: people pre-reflectively appraise their immediate situation in terms of what they encounter (e.g., feeling distracted by a loud phone ring). 3) *Interpretation*: people evaluate their experience on the level of cognition. 4) *Reflection*: people reflect on and re-examine their experience. 5) *Appropriation*: people give shape to a new experience by comparing and associating it with their past experience. 6) *Experience sharing*: people share their lived experience with others by telling it or posting it on social networks.

Overall, these two models provide a useful lens through which to understand and analyze users' experience with technology. For example, O'Brien and Toms (2008) apply the four experiential components to investigate user engagement with technology. They designed the interview questions and

analyze the data based on four “threads.” Regarding the model of technology as experience, Hassenzahl et al. (2010) especially examine the relationship between “need fulfilment” and emotional appraisal in experiencing interactive artifacts.

2.4.6 Discussion on experience models

The experience models are summarized to obtain a holistic view in terms of the four dimensions of experiences and contexts (Table 2.2). There are many overlaps between audience experience (Bildt, 2011; Heeter, 2000; Walmsley & Franks, 2011), brand experience (Brakus et al., 2009; Khana & Rahmanb, 2015; Lee & Kang, 2012), user experience (Desmet, 2002; Norman, 2005; von Saucken & Gomez, 2014), consumption experience (Schmitt, 1999; 2009), and experience with technology (McCarthy & Wright, 2004). The authors of these various concepts of experience draw upon several core psychological insights to develop their models. User experience is mainly generated in the process of physically interacting with a product, which results in aesthetic perception, emotional experience, and meaning, as Desmet and Hekkert (2007) explore. Compared with user experience and brand experience, audience experience places less emphasis on the functional aspects of art works, while bodily and emotional responses are very important to audiences experiencing interactive art. Furthermore, people’s use of a product in everyday life is usually a long-term experience, while audiences’ engagement with ambient media is relatively immediate. In a sense, the audience experience of ambient media is located in a region between experience with interactive art and experience with a brand, as numerous ambient media designs draw upon interactive media (art) to engage audiences in interactions with brand-related stimuli, whereby brand personality is embedded in both embodied metaphor and meaningful action.

Differing from the models of brand experience proposed by Schmitt (1999) and Brakus et al. (2009), the model of audience experience by Bilda et al. (2011) is grounded in empirical studies on audience engagement with interactive art works in terms of the temporal dimension. Detailed qualitative data of audience experience are generated from observing and recording bodily actions during the interaction process, and audience intentions and expectations can be derived from both the observations (of real-time interaction) and interviews (conducted after participation). Compared to “the gulfs of execution and evaluation” (Norman, 1988, p. 47), this model reveals several characteristics of audience experience. At the beginning of an interaction with a product, the user usually has the intention to achieve a specific goal, such as opening a door to access a room, whereas an audience may not have specific intended goals in starting to interact with ambient media or an interactive art work, as people visit art shows for relaxation purposes or walk by ambient media in public spaces with no prior expectations (initial encounter). The audience needs to adapt to the setup of an artwork, thereby learning how to perform and what feedbacks. Through adaptation, the audience can develop a mental model and gain a limited knowledge about how to act with the work (adaptation), thereby possibly anticipating the interactive system’s response to their intentions. The audience thus achieves a better understanding of the work and intends to make their body act in ways that elicit corresponding feedbacks (anticipation). Furthermore, the audience may extend their intentions to obtain different outcomes by changing and trying new actions. Finally, the audience may feel surprised at the results triggered by their actions and either stop or continue interacting with the system (deeper understanding). Audience experiences with ambient media have more uncertainty, as ambient media may provide audiences with unexpected (positive) feedbacks rather than offering practical utility through the use of products.

Having examined several phenomenological insights about experience, user experience in product design, consumer experience, brand experience, audience experience, and technology as experience, this research intends to conceptualize audience experience in consideration of this study’s scope and framework. To describe people experiencing ambient media, this research adopts the term “participating audience,” which refers to the persons who actively participate in interaction with ambient media. The term “audience” is widely used in studies on interaction in public space (e.g., Hespanhol & Tomitsch, 2015; Wouters et al., 2016). Given that people have different roles in the interaction process (e.g., passerby, bystander, participant, and actor), Wouters et al. (2016) adopt the term “audience” to refer to those various roles. This interpretation is applicable to ambient media and the term "audience experiences" in this article refers to "participating audience's experiences."

	Perceptual process	Emotion	Cognitive process	Action	Disciplinary background
Three layers of experience (Norman, 2005)	Senses, Visceral response	Appraisal of Visceral, Behavioral, and Reflective levels	Reflective level response	Motor actions	Product design Interaction design
Product emotions (Desmet, 2002)	Product’s appearance	Emotion	Concern Appraisal	n/a	Product design
Product experience (Desmet & Hekkert, 2007)	Aesthetic experience	Emotional experience	Experience of meaning	n/a	Product design
Unified user experience Model (von Saucken & Gomez, 2014)	Product, environment, perception, aesthetics	Experiencing & emotion	Mental model, reflection, evaluation	Action	Across the design field
Experiential marketing (Schmitt, 2009)	Sensing	Feeling	Thinking Relating	Acting	Marketing management
Brand Experience (Brakus et al., 2009)	Sensory response	Affective response	Intellectual response	Behavioral response	Marketing
Audience experience (e.g., Bilda et al, 2006, 2008)	Multi-sensory responses	Emotional response Unexpectedness	Intellectual response	Bodily actions	Interactive art Media Advertising
Technology as experience (McCarthy & Wright, 2004)	Sensual thread	Emotional thread	Compositional and Spatiotemporal threads	Compositional and Spatiotemporal threads	HCI

Table 2.2 Summary of experience models

In consideration with the multi perspectives on embodiment and experience, similarities and differences exist between the above models. Each model

focuses on understanding experience in its specific research field. Firstly, perceptual response is the fundamental element in all experience models. The main difference between them is that the stimuli vary from product to environment and other specific contexts (e.g., advertisement, interactive installation). Secondly, all models are concerned with emotional and cognitive aspects of experience, but their specific expressions vary (e.g., affective, feeling, appraisal, reflection, relating). The models of Desmet (2002) and Norman (2005) consider that emotional experience results from other levels of experience (i.e., sensory and cognitive), while other models treat emotion as an individual level.

With regard to embodiment, most models concern human's actions except the two models (Desmet, 2002; Desmet & Hekkert, 2007), but they have various scopes and implications. Only the model of audience experience (Bilda et al., 2006) explicitly describes that the bodily action is one key aspect in audience experience and cognitive processing, whereas the other models generally describe behavior or acting as one aspect of experience. Norman's model (2005) focuses on the functional aspect and usability of user's actions rather than embodied meaning of bodily actions. Although most models are not based on embodied approach, they provide comprehensive insights on experience, which help to gain a clear understanding on audience experience in the context of ambient media.

Based on the insights on experience derived from a range of research fields, the current research conceptualizes audience experiences as follows: "audience's sensory, emotional, kinesthetic, and cognitive responses that are elicited from embodied interactions with ambient media." This definition provides a framework for understanding and analyzing audience experiences with ambient media. More specifically, this research focuses on understanding embodied experience, which comprises the sensory, motor,

and kinesthetic aspects of audience experiences and their relations to cognitive responses.

2.4.7 A clarification of three concepts of experience

Although audience experience is a central concept in this research, three other concepts are also mentioned: bodily experience, meaningful experience, and embodied experience. Despite their different usages, they are closely interrelated. This section attempts to clarify these terms in regard to their differences and similarities. First, the term “bodily experience” is widely used in many studies on cognitive linguistics and interaction design (e.g., Gibbs & Wilson, 2002; Lakoff & Johnson, 1999; Loke & Robertson, 2013; Van Rompay & Hekkert, 2001). In general, bodily experience refers to people’s direct responses to their bodily interactions with the environment. More specifically, it regards sensory and kinesthetic responses in interactions. As reviewed in section 2.3.2, people’s bodily experiences underlie their mental patterns and influence how they understand concepts and comprehend meanings. Second, the term “meaningful experience” also frequently appears in many publications in the field of HCI (e.g., Ludvigsen, 2006; Rahaman & Tan, 2009; Von Saucken & Gomez, 2014). Meaningful experience indicates that people can make meaning in experiencing interactive systems and connects people with value, accomplishment, understanding, remembering, and creation (Diller et al., 2005). Finally, embodied experience emphasizes that people’s experience is grounded in their bodily interaction with physical spaces and objects (Gibbs, 2005; Hoby & Löwgren, 2011; Hornecker et al., 2017; Moen, 2007). Based on these aspects, the concept of embodied experience highlights the underlying connection between meaningful experience and bodily experience (Figure 2.9).

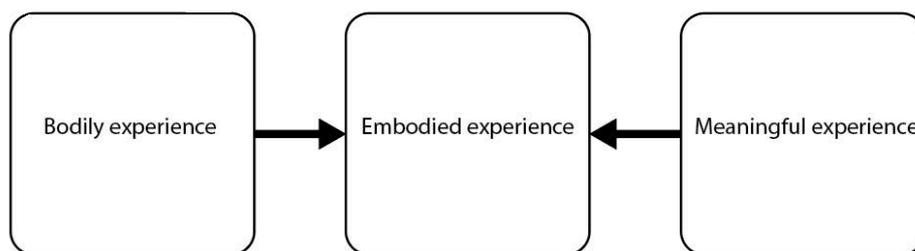


Figure 2.9 Three concepts of experience

As stated in the previous section, a main aim of this research is to understand audience's embodied experience, which regards how the sensory-motor aspects of audience experiences influence meaning making in interacting with ambient media.

2.5 Theoretical framework

This chapter centers on clarifying a range of key concepts and theories. The first section delineates the meaning of ambient media in the context of this research. Subsequently, three key properties (i.e., spatiality, unexpectedness, and engagement) are identified to provide a unique position regarding the scope of ambient media, and the interrelations between the three properties are also clarified. Embodiment, as a central theoretical idea in this research, is examined from various fields (phenomenology, cognitive science, cognitive linguistics, and HCI). The review considers that the phenomenological essence of "ambient" is grounded in the idea of embodiment presented in the views of McCullough (2013) and Dourish (2001). The third part provides a holistic review of the concept of experience and defines audience experiences in terms of four dimensions. It also indicates that the main focus is sensory-motor experience and its relations to cognitive responses (meaning making). Finally, the concept of affordance is not only key in interaction design but also in the study of embodied interactions with ambient media, as it is closely

related to the physical features of public space and bodily actions. This research dedicates special attention to the bodily and meaningful properties of embodied interactions, as well as to the relationship between bodily engagement and meaning making in interacting with ambient media.

Based on the examination of related theories and studies, two major RQs are developed:

RQ1: *How can audience experiences with ambient media be understood from an embodied cognition perspective?*

RQ2: *How can a design approach be developed to support embodied interactions with ambient media?*

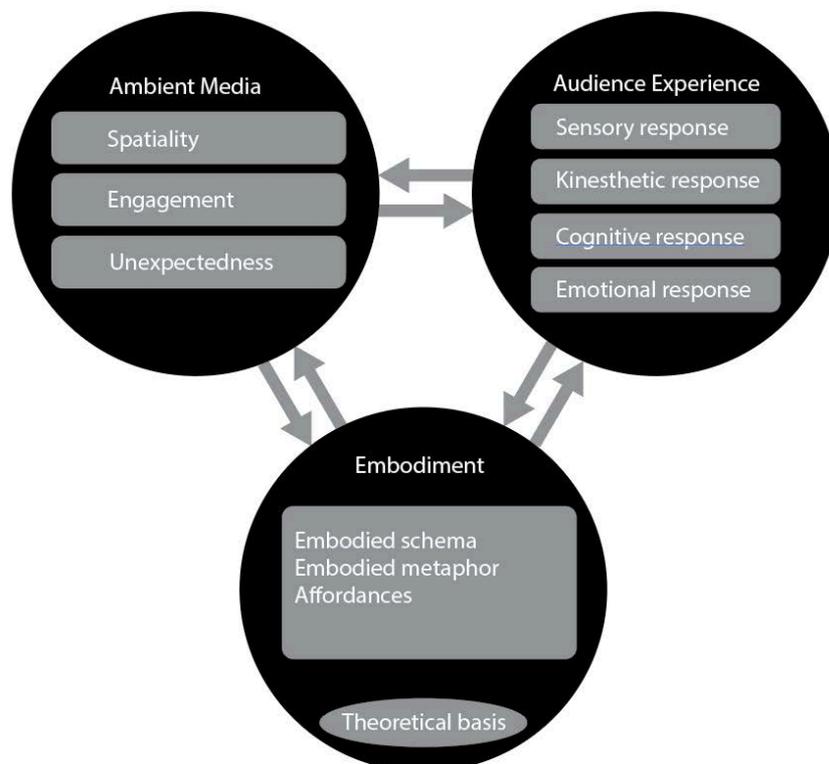


Figure 2.10 The theoretical framework of ambient media design

As mentioned in Chapter 1, corresponding sub-questions and research objectives are also identified. Accordingly, this research has two main objectives: first to understand participating audience's embodied experience in interacting with ambient media and second to develop an approach to designing embodied interactions with ambient media.

The theoretical framework is presented as a diagram (Figure 2.10) by synthesizing the above review on relevant theories and concepts, and consists of three main components. First, ambient media comprises the main body of this study and its three properties are interrelated with the elements of embodiment and audience experiences. Next, embodiment provides phenomenological insights for research on ambient media design and in investigating the mechanism between bodily engagement and meaning making. The notions of embodied schema and embodied metaphor are expected to inform the exploration of an approach to designing meaningful interaction with ambient media. Finally, facilitating audience experiences is the major goal of ambient media design, and the major factors of audience experiences are identified through interpretive and empirical studies in regard to embodied interaction.

As Maxwell (2009) suggests, theoretical frameworks can provide researchers with new insights and extend their understanding of a certain phenomenon. The function of a theoretical framework is to inform the research design (methods), identify the main content (factors or variables) to be studied, and lead to presumptions on the relationships between variables. This framework offers a comprehensive basis for developing a methodology and research design, and the next chapter focuses on methodological considerations based on the theoretical framework.

Chapter 3. Research Methodology and Design

3.1 Introduction
3.2 Research paradigm
3.3 Rationale for methodology
3.3.1 Reflection on research questions
3.3.2 Qualitative methodology
3.3.3 Research through design
3.4 Research design
3.4.1 The research design model
3.4.2 The research design structure
3.4.3 Validity
3.5 Summary

3.1 Introduction

This chapter, which focuses upon discussing methodological considerations and developing a feasible research design, describes the underlying philosophical assumptions and rationale for the applied methodological approach. This, in turn, provides a framework for formulating the research design and conducting further studies. Accordingly, interpretivism is identified as the main research paradigm, but this research also possesses particular footprints that lead to pragmatism. Based on the interpretive paradigm, this research mainly follows a qualitative methodology to collect, analyze, and interpret data, while research through design (RtD) generates new understandings with regard to designing ambient media for meaningful experiences. In addition, simple quantitative data provides statistical evidence to support the interpretive analysis. The methodological considerations are discussed in three sections: the research paradigm, the rationale for the methodology, and the research design.

3.2 Research paradigm

Before formulating a feasible research design, this research firstly needs to attend to the philosophical paradigm that structures the nature of the whole research approach. According to Kuhn (1962, p. 45) and Scotland (2012), a research paradigm is a common framework recognized by scholars within a research community, and it encompasses three major philosophical assumptions: ontology (what is the nature of reality?), epistemology (how can a researcher understand reality?), and methodology (how can research be conducted?). These assumptions provide a set of inquiry guides for addressing problems and exploring new knowledge. There are four types of research paradigms within qualitative research (Creswell, 2007, p. 19): post-positivism, constructivism (interpretivism), advocacy, and pragmatism.

Interpretivists seek understanding of the society in which they live through interpretations of the subjective attitudes and perspectives of a situation that lead to meaning construction and theory development. Consequently, research within the interpretive paradigm relies on the observation and interpretation of people's lived experiences. For this reason, the roles of researchers can be as observers, interviewers, analysts, or even participants. The interpretive paradigm commonly employs meaning-oriented approaches which include phenomenology, ethnography, grounded theory, action research and so on. Sometimes, however, it may be combined with other approaches such as case study, or research through design. Interpretivism is inherently grounded in phenomenology, and, in particular, in hermeneutic phenomenology. As reviewed in Chapter 2 (2.2.1), phenomenology explores the way humans experience their surrounding environment and what the meaning of that experience is (Dawson, 2013). Phenomenologists attempt to discover an act's meaning through interpreting the intentional nature of the act (Jacob, 2014; McIntyre and Woodruff, 1989; Smith, 2013). Hermeneutic

(interpretive) phenomenology is considered to be both a branch of philosophy and a methodological approach, which focuses on the interpretive structures of experience, and the ways in which people make sense of and engage with the surrounding environments (social and natural) from both first-person (researchers) and third person (participants) perspectives. Hermeneutic phenomenology is a highly effective approach in eliciting personal experiences from the participant's perspective (Pelleth, 2010). Adhering to the interpretive paradigm, this research interprets and understands the different dimensions of an audience's embodied experiences with ambient media through case study and experience testing. For example, investigating the underlying relationship between bodily interaction and embodied metaphorical meaning making may be tacit and implicit, but it may become explicit when the researcher can derive and interpret textual meanings from participants' reports and behaviors. In this case, the theoretical framework is crucial to providing scientific justification for the ensuing interpretation or meaning construction.

On the other hand, this research also has some features of another paradigm – pragmatism. Within this paradigm, researchers concentrate on the pragmatic outcomes of the research (e.g., actions, situations), such as solutions to a problem, and they can utilize different approaches (e.g., qualitative, quantitative) to collect and analyze data (Creswell, 2007, p 23). In design research, the pragmatist paradigm emphasizes that design theories and assumptions should be continuously tested in practice in order to evaluate their value (Dalsgaard, 2014). This research proposes that embodied interactions may facilitate meaningful experiences with ambient media, which, therefore, need to be evaluated through empirical studies on audience experiences. Furthermore, research through design has been developed as an important methodology within the design research community (Gaver, 2012; Jonas, 2015; Zimmerman et al., 2007, 2010). Design researchers develop new

knowledge through design practice that is regarded as an approach of inquiry. This is consistent with the tenet within pragmatism that new knowledge is formed from direct engagement with the situation (Rorty, 1991, p. 1).

In order to understand audience experiences with ambient media, this research may derive qualitative data from ambient media works (e.g., videos or pictures), direct observation of the interactions between the audience and ambient media works, and also participant interviews, thereby interpreting meaning from this qualitative information. This engages the researcher in the whole process of collecting data pertaining to embodied experiences (e.g., perception, cognition), interpreting the meanings of the experiences, and analyzing the structures of the experiences. The researcher may also reflect upon the processes of ideating, prototyping, and experience testing, and generate constructive ideas about ambient media design.

In the context of this research, Table 3.1 depicts the philosophical assumptions inherent within the interpretive paradigm in terms of research aims and the three philosophical assumptions, which construct a philosophical framework for investigating audience experiences with ambient media and exploring ambient media design.

Aims of the research	<ul style="list-style-type: none"> • Understand the audience’s embodied experience with ambient media and interpret its key factors and analyze their relationships. • Develop an embodied design approach to inform design ideation and experience evaluation.
Ontology	<ul style="list-style-type: none"> • Audience experiences are subjective and multiple. • Audience experiences are elicited from embodied interactions with ambient media.
Epistemology	<ul style="list-style-type: none"> • The audience’s embodied experience can be explored through investigating people’s engagement with ambient media • The researcher, as an instrument, gathers information of the audience experiences.

	<ul style="list-style-type: none"> • The researcher, as a participant, engages in designing ambient media.
Methodology	<ul style="list-style-type: none"> • Qualitative methodology (case analyses, collecting qualitative data through observation and semi-structured interviews, interpreting meaning from texts and videos) • Research through design (reflecting on the process of designing, interpreting meaning from first person experience)

Table 3.1 Philosophical assumptions of interpretivism

3.3 Rationale for methodology

3.3.1 Reflection on research questions

This section identifies and justifies the methodological approach used to conduct the study. In order to determine a specific research approach, it is necessary to consider the nature of this research. The theoretical framework was established in Chapter 2 after reviewing the relevant theories and studies. This framework gives rise to the presumption that bodily interactions elicited by spatial features can facilitate meaningful experiences with ambient media. In regard to this assumption, two main research questions were identified (as cited in Chapter 1):

RQ1: How can audience experiences be understood in interacting with ambient media from an embodied cognition perspective?

RQ2: How can a design approach be developed to support meaningful interaction?

Driven by the research questions, this research is able to identify an appropriate methodological approach for the research design. The two research questions are interrelated. The objective of understanding audience experiences with ambient media is to explore a holistic and strategic approach to designing ambient media with regard to how it can offer workable

instruments to designers and benefit the design ideation process. RQ1 denotes the features of descriptive and interpretive research, as understanding audience experiences requires interpreting meaning from subjective experiences. The interpretive approach aims to understand phenomena and gather open-ended information through directly investigating participants' experiences (Creswell, 2007). On the other hand, RQ2 embodies the characteristics of exploratory research such as RTD. Interaction design researchers generate new knowledge through engaging in iterative design development (e.g., prototyping and testing), which blurs the role between researcher and designer (Dalsgaard, 2014; Jonas, 2015; Zimmerman et al., 2010). Research through design is also a process of describing, interpreting, and reflecting on developing artifacts, and the reflections of the researchers (designers) themselves can be a form of design evaluation (Gaver & Höök, 2017).

3.3.2 Qualitative methodology

In consideration of its descriptive and interpretive nature, this research mainly follows a qualitative methodology to collect, analyze and interpret data, while simple quantitative data provide statistical evidence to support the interpretive analysis. Qualitative research is primarily concerned with understanding the "quality" of phenomena such as the attitudes, behavior, opinions, and situations of individuals or groups. Researchers, as the main instrument, collect qualitative data (e.g., words, pictures) through observing and interviewing people. Qualitative researchers believe multiple approaches (e.g., phenomenology, grounded theory) to making sense of people's experiences (qualitative data) exist. This research is to interpret and understand different dimensions of audience's embodied experience with ambient media through case study and experiment testing. In order to understand the tacit knowledge about the relationship between bodily

interaction and embodied metaphorical, the researcher attempts to derive and interpret textual meanings from the participant's reports and behaviors.

Qualitative research examines the complex relationships between various factors in certain situation rather than mere cause-effect relationships. Maxwell (2009) proposes the following five research goals in qualitative research: 1) Understanding the meaning emerging from the qualitative data reflecting participants' engagement with various situations and lived experience. 2) Investigating a particular situation where the participants interact with and experience certain subjects, and the relationship between the situation and participant's behaviors. 3) Finding new factors (phenomena) that contribute to new knowledge, theories, and methodologies. 4) Understanding the processes during which events and interactions occur. 5) Analyzing causal relationships in terms of the in-depth consideration of mechanisms rather than simple demonstrations between variables. Evidently, these goals accord well with the objectives of this research. Interacting with ambient media means that participants undergo an experience in a certain situation, which gives rise to experiential meanings in different dimensions that need to be understood through research utilizing the qualitative methodology. Interpreting and analyzing qualitative data may identify unanticipated themes or variables through an inductive process. Accordingly, "understanding processes" is twofold within this research: it is to investigate audience experiences through experience tests, and to understand the process of designing through ideation and prototyping.

3.3.3 Research through design

RtD has been developed as an important methodology in design research, and has been particularly discussed in HCI and interaction design (Gaver, 2012; Jonas, 2015; Koskinen et al., 2011; Krogh et al., 2015; Zimmerman et al., 2007, 2010). The concept of RtD originated from Frayling's definition of "research

through art and design” (1993). The basic idea of RtD is that researchers explore new understandings and generate new knowledge by using methods from design practice (e.g., prototyping, testing), and developing design as a process of inquiry into research (Zimmerman et al., 2010). Research through design can be seen as a research approach within the pragmatism paradigm, which emphasizes that the researcher, as a reflective practitioner undertaking actions within a situation, engages in action-oriented events to experience and understand a situation (Dalsgaard, 2014; Wright & McCarthy, 2010, p. 92). Research through design also can be considered a process of describing, interpreting, and reflecting on developing artifacts, and the reflections of researchers (designers) themselves can be a form of design evaluation (Gaver & Höök, 2017). Krogh et al. (2015) believe that design experiments are a key means of inquiry in RtD, and they propose five types of design experiments to guide the design process within RtD. This illustrates the methodological perspective of RtD and the relationships between various cases and phases embodied in sketching and prototyping. Zimmerman et al. (2007) propose four criteria for evaluating RtD in interaction design: 1) Process: interaction design researchers should adopt a rigorous research process in RtD and present a rationale for applying specific methods in detail, which can be accessible to and reproduced by other studies. 2) Invention: RtD should produce original and novel design strategies or understandings of a particular situation that advance existing knowledge. 3) Relevance: researchers should provide articulation about why the new state they favor is preferable to the current situation. 4) Extensibility: Rtd should allow the community to maximize the value and impact of the knowledge derived from the resulting outcomes.

In spite of its unique properties, RtD is essentially interwoven into qualitative methodology, and conducting design experiments requires a qualitative description of the research goals and process, and the interpretation of the

outcomes from design experiments (Krog̃, 2015; Krog̃ et al., 2015). The qualitative characteristics of RtD are embodied in thematic open-ended hypotheses and exploratory inquiry. Sketching is the primary means by which design ideations can be described and evaluated for their quality and situation in respect to a design problem. Research through design is both a deductive (theory informing practice) and inductive (practice informing theory) process, and design knowledge is situated in the artifacts and creation process.

Deriving the findings as guidance from the interpretive studies on audience experiences, the research aims to explore new approaches to designing ambient media by using methods from RtD. Case study and interpretive studies on experience tests provide understandings of the mechanism of embodied meaning making based on bodily engagement, and the relationship between spatial features and bodily interactions. This may give rise to preliminary design strategies and models for designing ambient media. Drawing on the RtD approach, the researcher may act as a reflective designer to ideate, sketch, analyze, prototype, experiment, describe, and interpret in a process of designing interactions with ambient media. As described in the many studies on RtD, the main anticipated contribution may provide an embodied design approach for researchers and designers, and benefit future explorations of embodied interactions.

3.4 Research design

3.4.1 The research design model

Research design is a logical work plan that focuses on how the research is actually conducted in order to achieve the objectives. It determines and synthesizes the specific methods and procedures used before the collecting and analyzing of data. Designing the research involves the creation of a logical structure for an enquiry that will answer research questions or test a theory

(De Vaus, 2001, p. 16). Based on the research paradigm and methodology articulated above, this section aims to formulate an overall framework for conducting the research in various study phases. According to Maxwell (2009), qualitative research design should consider five essential aspects (Figure 3.1) in planning a methodological framework: research questions, research goals, the conceptual framework, methods, and validity – all of which are deemed an integrated and interrelated unity. The research design adopted this model as a guide to developing a further framework.

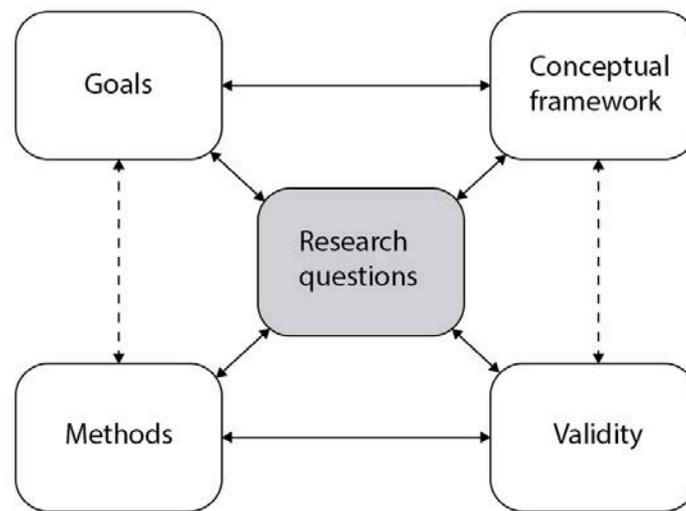


Figure 3.1 The research design model (adapted from Maxwell, 2009)

This model features two sets of triangular relationships. The first upper triangle is the relationship between the research question, the goals, and the conceptual framework, which were examined in previous chapters. The two research questions (see 3.3.1) are the core components in research design, which determine what objectives should be targeted and what theoretical perspectives should be considered. However, research questions are also informed by the existing theoretical insights and models. Secondly, the bottom triangle represents the close relationship between the research questions, the methods, and validity. In research design, the chosen methods should be able to answer the research questions, and they must ensure that

the findings can be validated. In addition, the paradigm and methodology discussed in the preceding sections have a direct influence on planning the research. Overall, the research questions should inform all the other components in this model, and designing a research plan requires rigorous consideration of the two triangular relationships.

3.4.2 The research design structure

Based on the research design model, this research addresses two basic questions: *“How can audience experiences with ambient media be understood from an embodied cognition perspective?”* and *“How can a design approach be developed to support embodied interactions with ambient media?”* This leads to the corresponding research goals: 1) *to investigate an audience experience model and meaning making in embodied interactions with ambient media*, and 2) *to explore an embodied design approach to informing ambient media design and embodied interactions*. The research questions and goals determine that the research design has both interpretive and exploratory features, and integrates both deductive and inductive processes. Chapter 2 has comprehensively reviewed the relevant theoretical ideas and concepts concerning ambient media, embodiment, cognitive semantics, and audience experiences. These theoretical and conceptual foundations provide key definitions, factors, and the underlying connections between them, which prompt the researcher to organize themes and codes for data collection and analysis. In short, the first triangular relationship between the three components constructs an orientation for the research design, while the second triangle considers the specific methods for data collection and analysis, with the aim of providing the evidence to answer the questions.

With regard to the relationships between the five components in research design, this research has designed a research structure that integrates the

previous assumptions with three studies, thereby, aiming to illustrate how the research is conducted (Figure 3.2).

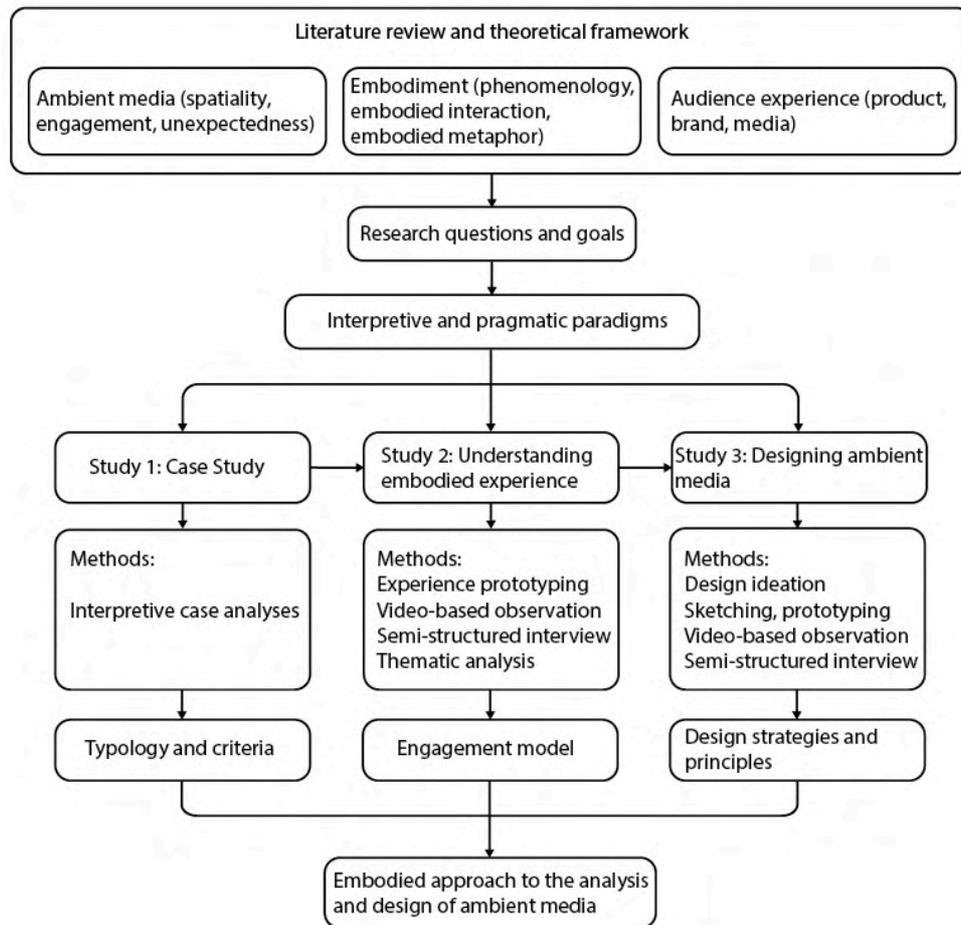


Figure 3.2 The research design structure

Apart from the triangular relationship between the theoretical framework, research questions, and goals, this structure highlights three sequential studies: the case study on ambient media works, the empirical study on audience experiences, and the study on designing ambient media. The three studies constitute a stringent and progressive research structure, as each study develops new models or instruments that help the next study analyze and experiment by following both the deductive and inductive processes. This research structure corresponds to the “Traditional Complex” thesis type (Paltridge, 2002), in which a “General Methods” chapter is followed by several studies that are presented as individual chapters. Thus, this section focuses

on discussing the overall research strategies and internal relationships between these studies, and the specific methods for each study are introduced in the following chapters.

3.4.2.1 Case study

Case study is an approach or strategy in qualitative research that focuses on understanding and in-depth analysis of one or more “case(s)” (e.g., event, person, or a design work, or designer in design research) within a particular setting or context. The study aim usually is not to construct theories but rather to understand a phenomenon. Many researchers have argued that case study is not regarded as a research method but an approach, given that in case study various methods can be chosen to collect and analyze data such as observations, and interviews (Laine, 2017; Mauda, 2016, p. 27; McLeod, 2008). Thus, a variety of data sources can be employed when conducting case study, including video recorded from observations, interview reports, field notes, and documents from websites and literature reviews.

Three considerations are important to a case study design (Creswell, 2007, p. 73-75). Firstly, researchers need to define precisely what the “case” is that they are attempting to study. In the context of design research, a case is a bounded unit (designer, company, design work), and the contextual factors also need to be taken into account. For example, a design work may have various meanings to users in different spatiotemporal settings. Ambient media is related to the spatial dimension, as it is defined as being situated in public space, and the scope and criteria then require further definition. The second consideration involves choosing the type of case study. In this regard, Yin (2009, P. 46) defined a matrix with a dimension of single- and multiple-case designs and a dimension of single- (holistic) and multiple- unit(s) (embedded) analysis, which constitute four types of case study designs. The third consideration is whether a case study requires theories to support its

analysis. A case study guided by theoretical propositions will be easier to conduct than one without theoretical considerations, and the former is usually related to deductive reasoning (theory testing), while the latter involves inductive reasoning (theory building).

Based on these considerations, the case study takes ambient media works as “cases” for analysis, and its main source is from existing documents (e.g., pictures, videos, descriptions) that reflect interactions with ambient media and embody the three attributes of ambient media (see 2.1.1). Secondly, the type of case study targets holistic multiple-case and single unit (holistic) design, which means that a range of ambient media works are analyzed in one single analytical unit. Thirdly, this case study aims to explore preliminary understandings of embodied experiences in interactions with ambient media. In consideration of the role of theory in case study, this study is primarily based on a deductive research process by employing the theories (e.g., embodied interaction, cognitive semantics) from the theoretical framework to analyze audience interaction with ambient media. Through deductive reasoning, the theoretical insights can be tested (De Vaus, 2001, p. 6-7), and may also give rise to more promising propositions that support further empirical studies. For example, one objective of the case study is to build a typology of ambient media. Through descriptive and interpretive case analyses based on embodied schema and experiential dimensions, ambient media works may be categorized into various types, which may suggest more explicit criteria for preparing the empirical study on audience experiences.

3.4.2.2 Empirical study on audience experiences

Empirical study originated from the epistemological standpoint of empiricism which believes that people acquire knowledge based on their sensory experiences. Empiricism emphasizes that experiments play an important role in discovering evidence, and theories and presumptions should be tested

through investigations in the natural world rather than relying on pure imagination and reasoning (Markie, 2017). Empiricism shares similar ideas with pragmatism, as both believe the human ability to understand and reason from something arises from physical experiences, and ideas or theories need to be tested in actual environments and through experiences (Hookway, 2013).

Both the natural and social sciences employ observation and experiments to empirically test presumptions and hypotheses. In the context of the qualitative methodology of this research, empirical studies specifically refer to qualitative empirical studies that collect data through experiments, direct observation, in-depth interviews, and focus group discussions. Empirical studies can generate plentiful, objective, in-depth contextual data (evidence) from the “field” to allow researchers to understand people’s experiences in a certain situation, differentiating them from studies that gather data from existing theories and documents. From the perspective of triangulation, empirical study can be a way to validate the data in a case study. Case study focuses on analysis and interpretation based on theoretical insights, and empirical study provides objective and first-hand evidence to support the presumptions of the theoretical and analytical study. According to Heitink (1999, pp. 234-235), the process of empirical study is comprised of five steps: observing an event, formulating a hypothesis, planning experiments, conducting tests (collecting empirical data), and interpreting data (building a theory).

Experiment testing, as a typical empirical method, is widely used to investigate user or audience experiences in interaction design research (e.g., Antle et al., 2011; Bianchi-Berthouze et al., 2007; Chow et al., 2016; Bilda et al., 2007; Loke & Robertson, 2013). For example, Bianchi-Berthouze et al. (2007) invited participants to experience two play modes of a game (normal game controller and guitar-shaped controller) to investigate the relationship

between bodily movement and the level of engagement. Chow et al. (2016) conducted user experience tests on an interactive mobile phone interface to understand people's metaphorical imagination and emotion. Bilda et al. (2007) investigated the audience experiences of interactive art works by asking participants to experience artworks and videotaping bodily behaviors, then interviewing the participants. In short, experiments on user experiences are a primary method in interaction design research, as they can elicit authentic and in-depth data embodying user or audience experiences.

Based on findings from the case study, the empirical study aims to investigate and test embodied experiences with ambient media through conducting experiments on a physical prototype in a public space. The main questions are: 1) What major factors of audience experiences can be identified? 2) What mechanism reflects the relationship between bodily states and cognitive experience? This empirical study combines the qualitative interpretive approach with the RtD approach. In order to collect empirical data on audience experiences, the researcher needs firstly to build an experience prototype as a test bed. Then, experiment testing is conducted to collect information about the participants' behaviors along with interview reports, which are analyzed qualitatively through thematic analysis. The findings are expected to reflect key factors within audiences embodied experiences with ambient media, as well as the relationship between bodily engagement and metaphorical meaning making.

3.4.2.3 Design experiments based on RtD

After conducting in-depth interpretive and analytical studies on audience experiences with ambient media, this research mainly addresses the second research question: "How can a design approach be developed to support meaningful interaction?" With regard to the nature of this research question, RtD, as discussed in 3.3.3, was chosen as a methodology to explore a design

approach that aims to benefit both the research and practice of interaction design in ambient media. Researchers explore new understandings of design by using methods from design practice (e.g., modeling, prototyping, experience testing), and reflect on the inquiry process into design research (e.g., Fällman, 2003; Ludvigsen, 2006; Wakkary et al., 2016). For example, Wakkary et al. (2016) presented four design guidelines through conducting an in-depth design experiment that involved designing, prototyping, and fabricating an interactive work, namely tilting bowl, which generated design knowledge about shifting from digital to physical prototyping and fabrication.

The findings from the case study and empirical study on audience experiences provide guidance with regard to exploring the design of ambient media toward a meaningful experience. Based on the RtD approach, this research is able to explore new design knowledge, strategies, instruments, and principles for designing embodied interactions with ambient media. Building on the typology of design experiments in RtD (Krogh et al., 2015), this study tries to employ an expansive design method to apply and test the findings from previous studies by developing a series of ambient media designs, and reflectively considering the design process. This expansive design study is focused on broadening and extending existing perspectives and models of embodied interaction design by means of conducting a series of design experiments. The researcher, as a reflective practitioner, engages in design activities to experience and understand the process of designing embodied interactions with ambient media. Through a process of ideation, sketching, prototyping, experimenting, and analyzing, this study is able to evaluate, validate, and reframe the previous models, and propose a feasible embodied design approach to designing ambient media.

3.4.3 Validity

Based on the research design model (Figure 3.1), validity is a key aspect that should be integrated along with the other four components. Rooted in the positivist paradigm, reliability and validity are terms commonly used in quantitative research. However, qualitative research also needs to demonstrate the ways in which the results are believable, and for this reason terms frequently employed in qualitative research are credibility, trustworthiness, confirmation, and dependability. The main difference between quantitative and qualitative research in coping with validity concerns is that quantitative researchers typically have prior controls (e.g., explicit hypotheses, control groups, variables, and randomized sampling) to rule out validity threats before collecting data, while qualitative researchers need to identify the possible threats to validity after beginning the research, and the evidence arising from the research is used to address validity concerns. Two major types of concerns arise from the qualitative research process: the researcher's presumptions (e.g., theories and values) and the specific methods for data collection. Firstly, the researcher's theoretical perspectives and presumptions may distort the ways in which the data is collected and analyzed, but it is impossible to ignore theoretical foundations and beliefs in qualitative research. To deal with this type of validity threat, researchers do not eliminate their existing theories and presumptions, but rather discuss potential biases and how to address them by taking these issues into consideration. Secondly, considering the influence of the researchers on the methods used for collecting data is important to addressing validity. Compared with observation, interviews in the data collection process are easily influenced by the researcher's behavior. For example, asking a question that elicits the answer the interviewer wants should be avoided. Understanding how the researcher influences the validity in data collection is necessary in research design.

Accordingly, Maxwell (2009) summarizes seven strategies (e.g., being involved in long-term observation, acquiring abundant and multi-source data) for coping with these validity threats, which offer a guideline for this research with regard to managing validity concerns, and the following validity issues are discussed in regard to specific studies.

3.4.3.1 Triangulation of methodologies and methods

Triangulation in this research is mainly embodied in two dimensions. The first is triangulating the research approaches and paradigms to investigate the research questions. As introduced in 3.2 and 3.3, this research has footprints in both the interpretive and pragmatic paradigms and employs both qualitative and RtD methodologies, aiming to provide a better understanding in order to address the research questions and achieve the research goals. In spite of their different approaches, Study 1 (case analyses) and Study 2 (empirical study) both aim to understand embodied experiences with ambient media. The case analyses are primarily based on the researcher's subjective description and interpretation of audience experiences with ambient media, with reference also to theoretical foundations from cognitive semantics and embodied interactions. This might lead to bias within the results due to the researcher's personal beliefs and the theoretical perspectives chosen. However, the empirical study can produce authentic and complementary evidence for better understanding the embodied experience with ambient media, as the experiments with the involved participants provide objective and behavioral data in real settings.

Secondly, a variety of methods, used in different research phases, are triangulated to generate diverse information reflecting the embodied experiences and embodied design approach. The three sequential studies draw upon various sets of methods for collecting and analyzing data. For the data collection, the data source of Study 1 is mainly online design documents,

and Study 2 focuses on collecting empirical field data of the participants' behaviors and verbal reports through observation and interviews, while Study 3 records the process of designing ambient media based on the researcher's self-reflections. The theoretical and interpretive analyses of the ambient media cases (Study 1) and the thematic analysis of the participants' reports (Study 2) are triangulated to enhance the validity of the research findings.

3.4.3.2 Collecting multi-source data

Collecting rich and multi-source information on embodied experiences with ambient media is a way to reveal a more holistic picture of tacit knowledge in the analysis and design of ambient media. The various range of methods used enable the researcher to collect various types of data about audience experiences such as perception, embodied schematic metaphorical mapping, and bodily engagement, as well as designing ambient media, which provide abundant information for both deductive and inductive research. In order to better understand the audience experiences, this research may review and gather online documents (i.e., videos, pictures, descriptions) about ambient media works, through which descriptive and interpretive data would be generated, and the researcher could conduct preliminary case analyses with regard to the embodied theories. After the initial results from the audience experiences analyses are obtained, the methods of empirical study are used to observe the participants' behaviors and interview them regarding their feelings and thoughts regarding experiencing an ambient media work, which is a way to validate the findings of the theoretical analyses in the case study. Directly observing the interaction between the audience and the ambient media work, interviewing participants, and interpreting meanings from the qualitative data engages the researcher in the complete process of collecting the data pertaining to embodied experiences. The observational data provides objective evidence to support the analysis of the participants' verbal reports.

In addition, the RtD method collects data about designing ambient media. The researcher, as both an observer and participant, ideates, sketches, creates prototypes, builds, tests, and reflects upon ambient media design works, and in this way a variety of data is produced including sketches, descriptions of ideation, physical prototypes, behavioral video recordings, verbal reports of experiences, and introspective reflections, which produce many possibilities for reframing and validating the findings (e.g., models and design strategies) of Studies 1 and 2. In addition, the four criteria for evaluating the quality of RtD (see 3.3.3) can also be feasible guidelines to increase validity in Study 3. For example, the researcher should articulate a rationale for using a certain method and plan rigorous research procedures, which can help other researchers apply the instruments or design approaches produced by RtD.

3.4.3.3 Comparison

Comparison is used pervasively in qualitative research, and is particularly useful in multiple case studies. For this research design, comparison is embodied in three aspects. Firstly, Study 1 conducted multiple-case analyses to derive preliminary understandings of embodied interactions with ambient media. The cases may vary in terms of environments, motor actions, sensory perceptions, image schemas, and metaphorical mappings. Through comparing the cases in regard to the elements of the audience experiences and ambient media identified in the theoretical framework, the researcher may be able to identify certain patterns or subtle differences in terms of different experiential dimensions and embodied metaphors across the cases. Compared with analyzing a single case, comparative analysis between multiple cases is expected to enhance the credibility of the study findings. The second dimension lies in the comparison between the interpretive case study and the empirical study. Comparing the findings of two studies can ensure the validity and reliability of the research, as theoretical case analyses can be

supported by the evidence of empirical study, while case study can inform empirical study of more specific factors that need to be investigated. Thirdly, Study 3 attempts to generate a range of designs by applying design strategies and models from the previous studies. Comparing these design ideas could be a way of validating and updating the embodied approach, and the relevant criteria for evaluating and comparing design ideas need to be established.

In short, these three strategies for coping with validity threats are interwoven. It is impossible to exclude all bias in research, but triangulating methods, collecting rich and divergent data, and comparing a range of design cases allow the research to exclude potential validity threats and increase the credibility and trustworthiness of this research.

3.5 Summary

In summary, this chapter has discussed the research paradigm and the rationale for the methodology, and demonstrated an approach that integrates qualitative and RtD methodologies, including potential methods for data collection and analysis. Based on the research design model, this chapter outlined the research structure which is comprised of three sequential studies: a case study on ambient media works, an empirical study on audience experiences, and design experiments, which are all closely interrelated. Three strategies were identified that aim to enhance the validity of the research. The next chapter conducts case analyses in order to understand embodied interactions with ambient media.

Chapter 4. Case Study on Ambient Media¹

4.1 Introduction

4.2 Analytical model for case study

4.3 Cases analyses

4.3.1 Moments of Warmth

4.3.2 Nike – Building Twist

4.3.3 Piano Staircase

4.3.4 Smooth Valentine’s Day

4.3.5 The Social Swipe

4.3.6 Bubble wrap in Bus Stop

4.3.7 Take a Seat, Make a friend

4.3.8 Smoking Causes Blindness

4.3.9 Europe. It's Just Next Door

4.3.10 Revolving Door

4.4 Discussion on case analysis

4.4.1 A framework of audience experiences in ambient media

4.4.2 Typology of ambient media

4.5 Summary

4.1 Introduction

In order to gain initial understanding on audience experiences with ambient media, this chapter focuses on conducting a range of case analyses by using an analytical model. The model is formulated guided by the theoretical framework (see Figure 2.10) and reflects the relationship between four experiential dimensions and embodiment. Ten ambient media works are chosen from existing documents and in line with the three properties of ambient media (see 2.2.1). In consideration with the role of theory in case

¹ Parts of the author’s own paper “Tan, L. and Chow, K.K.N. (2016). *An Embodied Interaction Framework for Facilitating Audience Experience with Ambient Media*. In the Fourth International Conference on Design Creativity (4th ICDC), J. Linsey, M. Yang and Y. Nagai Eds. The Design Society, Atlanta, GA, USA, 1-8” are included in Chapter 4. Longer sentences, phrases, and paragraphs are referenced.

study, it is primarily based on a deductive research process by employing the theories from theoretical framework to analyze audience interaction with ambient media. Through descriptive and interpretive analysis, this case study contributes to developing a more explicit framework of understanding audience experiences and embodied interactions with ambient media.

4.2 Analytical model for case study

As mentioned in Chapter 3 (see 3.4.2.1), case study has been extensively used in design research. Researchers can gain patterns and identify key factors from some phenomena through investigating cases. In some sense, case study is not a purely single method, whereas it also involves comparative analysis, interview, observation and other methods, and some researchers consider it as a research strategy. This section reviews three case studies relevant to ambient media and interaction design, which is aimed at informing the analysis of ambient media works.

Rahaman and Tan (2009) investigated interactive spaces through a case study. Referring to the review (3.4.2.1), their study belongs to multiple case and holistic (single unit) Design, as they investigated 16 cases and holistically analyzed these cases in a descriptive way. The source of cases was primarily from websites and papers. After making a descriptive analysis on the cases, they built a typological model to get an initial structure for further data analysis. Then these common attributes of interactive spaces were applied to the case analysis. By comparing these different attributes distribution, a pattern of interactive space was identified. Bargenda (2015) conducted two case studies to investigate how corporate architectures can serve as ambient media to convey brand value by using semiotic concepts. She drew upon semiotic notions as the model for analyzing the semiotic meanings of the two banks' architectural design in terms of the three sign types - icon, index and

symbol. Based on the handout from the course, the two case studies used multi-case and embedded (several units) design, since two cases were studied in terms of three units (sign types). The evidence of the cases was from the researcher's direct observation and taking photographs in the sites. After the two case studies with qualitative comparison, the researcher developed a design model in the discussion part, which extends the previous ambient media's scope and sees the spatial elements as the media carrying emotional, epistemic and social meanings. Jeong and Seungho (2013) investigated the participants' engagement in digital media art exhibition by conducting case studies. Building on the theories of affordances from various researchers, they create an analytical model comprising two dimensions: reaction levels of participants and components of exhibition, which is used to analyze a range of art exhibition works. This study means that an interactive media work is completed in a collaborative relation between the artist and the participant who acts as the action's performer and the output's receiver.

Based on these studies, this research devises an analytical model (Table 4.1) by integrating key components of the theoretical framework, which is used for descriptive and interpretive analysis on relevant cases of ambient media. This model is mainly constructed by four dimensions of audience experiences, in terms of which the three properties of ambient media and metaphorical meaning making are analyzed. Referring to Section 2.3.3, Table 4.1 adopts the definitions from Hartson (2003) and Morie et al. (2005). Perceptual affordance concerns the properties of an ambient medium that offer possibilities for perceiving sensory information (visual, tactile, and auditory sensations). Emotional affordance is about the design features that can give rise to an emotional response. Physical affordance refers to the actual and physical features that can support people in performing actions. Intellectual affordance is the design characteristic that can lead audience to think about and understand the meaning or function of acting with ambient media.

Embodied schemas and embodied metaphors (see 2.3.2.3) are used to analyze the cognitive experience, and they offer an insightful lens for the analysis of motor-cognition mechanism. Many studies in HCI have placed focus on the role of metaphor in visual interface design and graphic elements. Rather, this study concentrates on how embodied schema and embodied metaphor can be used to analyze the metaphorical mapping between bodily actions and meaning making.

The case analyses are aimed to gain initial understanding on the mechanism of meaning making and bodily interaction, which is expected to support further empirical research.

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceptual affordance	Emotional affordance	Physical affordance	Intellectual affordance
Metaphorical meaning making	Multi-sensory characteristics, Visual metaphor	Emotion is metaphorically elicited by bodily interactions	Bodily actions involved in embodied metaphor	Embodied schema & Embodied metaphor
Engagement	The relationship between engagement and four experience dimensions			
Unexpectedness	The relationship between unexpectedness and four experience dimensions			

Table 4.1 Analytical model for audience experiences in ambient media

4.3 Cases analyses

Based on the analytical model, this section investigates audience experiences and embodied interactions through descriptive and interpretive analysis on ten ambient media works. This case study is a type of multiple case and embedded design, and the source is retrieved from design companies' websites and academic literature.

4.3.1 Moments of Warmth

An interactive ambient media work was sponsored by battery brand Duracell (Truly Deeply, 2014). It transformed a bus stop into an ambient media work (Figure 4.1), where people could activate the electric heaters mounted on the top of bus shelter by touching the two sides of the shelter. The activation would not happen for only one person, because the both sides are too far for one person to touch. This constraint allows more people to connect their hands together to trigger the sensor for heating, and the actions metaphorically represent that solidarity and synergy can generate power and heat, which contributes to an embodied metaphor structured by embodied schema Part-Whole. The bodily actions actually triggered the unexpected feedback (warmth in cold winter) in a conventional location (bus stop) by engaging people in interaction with the installation and each other. The interaction led to the multi-level experience, including tactile sensation (warmth), visual sensation (glowing light from the heater), emotional experiences (pleasure, emotional warmth), and kinesthetic experiences (bodily actions).



Figure 4.1 Moments of Warmth campaign (Truly Deeply, 2014)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances
	The shape of the roof of the bus shelter is perceived as a battery, and the hand-shape graph indicates the area for putting hands. Red color of the shelter and the heater serve as sensory affordances.	Warmth generated from the roof of the shelter evokes audiences' emotions of content and pleasure as well as social warmth. Connecting with each other makes audiences have intimate and collaborative feelings.	The plates on both sides of the shelter offer the action possibilities of placing hands on them. The distance between the two walls offers the potential actions of holding users' hands.	The sentences printed on the walls enable audiences to think and know some contents of this campaign. The bodily interactions evoke both interpersonal communication and brand personality.
Metaphorical meaning making	Visual (color and shape) and tactile (touch and warmth) sensations	Emotional warmth is elicited with the heat on the top.	Connecting with each other by holding hands	Part-Whole schema: Joining hands together metaphorically represents solidarity and synergy for generating power and heat
Engagement	Passersby are engaged in bodily interactions by the setting of the shelter.			
Unexpectedness	The battery-like shape of the shelter brings initial surprise. The heat triggered by the bodily actions elicits unexpectedness			

Table 4.2 Analysis on Power of Warmth campaign

4.3.2 Nike – Building Twist

An ambient media campaign was built for NIKE by using 3D-mapping projection on the buildings (W+K Tokyo, 2012). This work was located in an old factory area of Yokohama, Japan, and the major goal was to advocate the shoes of Nike Free that could bring supernatural strength to those who wear them. To highlight the concept of flexibility, Nike hoped to use the shoe model

of Nike Free as an element for design. A sensor-embedded shoe was designed as an input interface, where an audience might be curious about it, and held, twisted, and or bend it. These physical actions were sensed and transferred as digital data, which resulted in the distortion of projection mapping on the walls. During this tangible interaction process, sensory, emotional, cognitive, and bodily experience were evoked by the corresponding affordances (see Table 4.3). For example, at the physical affordance level, the flexible shoe might provide the possibilities for audiences to twist or bend it. At emotional affordance level, the projection’s deformation resulting from the audience’s actions brought excitement and unexpectedness to audiences.

For the embodied metaphor, the actions of twisting the shoe resulting in real time animation of 3D mapping metaphorically denote high flexibility in the campaign. The meaning making of interaction with this ambient media work involves two embodied schemas: the bodily action of twisting shoe and sensory feedback of shaking buildings are structured by Counter-force and Balance schemas.



Figure 4.2 Nike - Building Twist (W+K Tokyo, 2012)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances &	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances

Spatiality	The shoe placed on the table can be accessed by the audiences. The projection mapping on the buildings can be viewed from a large distance.	The shoe's flexibility leads to the buildings' deformation and brings excitement and unexpectedness to audiences.	The flexible shoe offers potentials for audiences to physically twist or bend it.	The actions and the perceptions elicit product and brand knowledge in cognitive level.
Metaphorical meaning making	Visual (light and shapes) sensation. Tactile (touching the shoe)	The distorted mapping on the walls elicits surprising and exciting feelings.	Twisting the shoe resulting in interactive 3D mapping is in line with the concept of supernatural flexibility in NIKE's campaign.	Counter-force and balance schemas: the actions of twisting the shoe resulting in real time animation of 3D mapping metaphorically denote high flexibility
Engagement	The shoe attracts the audience's attention. The projection of shaking building engages the audience in further bodily interaction.			
Unexpectedness	The distortion of moving images on walls brings surprising responses.			

Table 4.3 Analysis on Nike - Building Twist

4.3.3 Piano Staircase

Piano Staircase was installed at the entrance of a metro station and connected the ground level with the underground level (DDB, 2009). An escalator was parallel to the staircase. Aiming to advocate healthy lifestyle, the designers of this work intended to encourage people to do more physical exercises by using the staircase rather than the escalator. Before this campaign, very few people took the staircase, but after that, most people chose to use the staircase. They were attracted by the piano-look of the staircase, and when they stepped on the stairs, the sound like piano would be played. With the music accompanying the stepping up or down, those audiences actively altered their postures and actions, and gained various feedbacks of music. These behaviors also drew

the attention of other people, as observers, who were not on the stairs and could potentially participate in interactions. The staircase, as an interaction interface, was played as a music instrument for fun, while the actions of stepping up or down were metaphorically mapped onto the pitch levels of musical notes, which is structured by Scale schema. In this case, the interactions between audiences and the staircase evoked emotional and cognitive experiences through continuing bodily engagement.



Figure 4.3 Piano Staircase (DDB, 2009)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances
	The piano keyboard designed on the staircase. The sounds triggered by the actions of audiences.	The appearance of the staircase like piano keys and the actions of stepping provide the possibilities of eliciting fun and curiosity.	The stairs looking like piano keys offer potentials of physically stepping up or down.	The bodily actions and the perceptions might elicit thinking of searching for a certain pattern of playing the music and healthy lifestyle.
Metaphorical meaning making	Visual sensation (piano keys)	Interacting with piano staircase elicits lively and	Audiences' whole body movements on the staircase	Scale schema: The spatial relation of walking up and down on the

	Hearing (sounds) sensations The staircase resembles the shape of piano keyboard	joyful experiences.		staircase is mapped onto the pitch levels of piano notes.
Engagement	The musical effects engage people in various bodily interaction. Bodily actions (e.g., walking, jumping) trigger various musical effects.			
Unexpectedness	The piano-like staircase is designed with an unexpected setting, and the musical effects brings surprising feelings.			

Table 4.4 Analysis on Piano Staircase

4.3.4 Smooth Valentine's Day

European razor brand Wilkinson Sword created an ambient media named "Smooth Valentine's Day" (JWT Paris, 2013). A wall-sized installation with a man's face was set on a public square in Paris, and if passers viewed from a far distance, the man on the picture had whiskers that actually were rose stems. When passers walked near the installation, they could recognize the rose stems penetrating the face of the man on the picture, and they might take one or several as a gift to their lovers. Each rose was bound with a small paper card on which Wilkinson's logo and a sentence "This is not the day to irritate her" were printed. With more and more passers taking roses, the stems (whiskers) were gradually moved away, and a clean face appeared. The metaphorical mapping from pulling rose stems to shaving beard is structured by Removal schema. Unexpectedness and warm-hearted experience would be elicited during these embodied interactions with ambient media, and the brand spirit and product features of Wilkinson also were embodied.



Figure 4.4 Smooth Valentine's Day (JWT Paris, 2013)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances
	The man's face and the rose stems penetrating the man's face.	Taking roses from the face could result in the enjoyable and warm-hearted behaviors of presenting to and sharing with others.	The roses installed on the picture offer the action possibility of taking them out.	The actions of taking roses from the man's face simulated the actions of shaving whiskers, which embodied the quality of the brand. The logo and the sentence on the card could elicit the cognition of the brand and the product.
Metaphorical meaning making	Visual sense (the picture and the stems).	Roses taken by passers metaphorically elicit sweet and lovely feelings.	Taking roses from the board	Removal schema: Taking roses from the board metaphorically denotes cleaning beard from the face.
Engagement	The placement of stems engages people in bodily interactions. People can pull roses out from the huge face.			
Unexpectedness	The huge face with many stems brings surprising experience.			

Table 4.5 Analysis on Smooth Valentine's Day

4.3.5 The Social Swipe

To encourage people to make donations, an ambient media work for charity donation was set up in Hamburg international airport. A slot for swiping was vertically mounted in the middle of the screen which displayed a loaf of bread or two hands tied by a rope. When walking closer to the installation, audiences would notice the sign above the screen that suggested donation of 2 Euros, and meanwhile the arrow lighting up hinted at the direction for swiping the credit card. Swiping simultaneously activated the animations of cutting off a piece of bread or a rope tying two hands, which indicates the simple donation could make improvement for poverty and hunger. Beside these bodily interactions, a bill of credit card will be mailed to the donator with a request of the monthly donation. This campaign had raised over €3,000 in the first month, and the number of donators who made three or more subsequent donations increased yearly by 23 percent (Kolle Rebbe, 2014). The embodied meaning of swiping credit cards is eliminating poverty and helping people in hunger, which is structured by Removal schema.

The Social Swipe was created as an active and engaging ambient medium to enhance people's willingness for donation. It also offered a lively and instant feedback, which allowed donators to feel their actions contributing to a positive outcome. The audiences who were donating could also have a sense of pride about their charity behaviors in public space.



Figure 4.5 The Social Swipe (Kolle Rebbe, 2014)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances
	Visual sensations (Installation, Signs, and Video) Hearing sensations (Audio)	Swiping a card in the slot simultaneously triggered the animations of cutting off a piece of bread and a rope tying two hands, which elicited sympathy and fulfillment.	The slot in the screen provided action possibilities of swiping a card.	The action of swiping credit card and the animations evoke the awareness of charity and positive action outcomes
Metaphorical meaning making	Signs, light, animations, and sound	The actions triggering cutting off bread and rope metaphorically elicit sympathetic and gratifying emotions.	Swiping a credit card	Removal schema: Cutting off the rope tying hands metaphorically denotes removing poverty, and cutting the bread means helping those in poverty and hunger.
Engagement	The slot and bread on the screen jointly indicates the action of swiping cards. The actions of swiping simultaneously lead to animations.			
Unexpectedness	The animation of the bread being divided and taken away by a hand brings an unexpected feeling.			

Table 4.6 Analysis on The Social Swipe

4.3.6 Bubble wrap in Bus Stop

The moment of waiting for buses is boring, and Sony turned the moment into an enjoyable experience by transforming the bus stops to an ambient medium (Sony, 2005). The elements of PS2's buttons on handle were embedded in the bubble wrap mounted on the wall of the bus stop. Passers could use their fingers to press these bubbles like playing the Sony's video games by striking the controller's buttons, and this unconventional approach made a very engaging and unique way to exhibit products to potential consumers, who might spend their waiting time popping the plastic bubbles with a playable and joyful experience. The bubble wrap was an embodied metaphor for PlayStation gaming and delivered the message "have fun in even the most boring places", while the PlayStation 2 logo is used as a familiar symbol for audiences to link to the PlayStation brand. This makes people feel attracted to the product because they already have somewhat of an understanding of what it could mean for them.



Figure 4.6 Bubble wrap in Bus Stop (Sony, 2005)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances &	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances

Spatiality	Passers can visually perceive logo and icon. Bubble wrap can be perceived to be touchable.	The game-related symbols and popping the bubble elicit engaging and enjoyable experience.	The bubble wrap induces action possibilities of pressing them.	The interactions with ambient media evoke audiences to get the message "make fun even in the very boring places".
Metaphorical meaning making	The symbols (Visual sensations), Pressing bubbles (Tactile sensations)	The symbols from controller buttons and popping the bubble elicit pleasure and fulfillment.	Pressing these bubbles simulates the experience of playing the Sony's video games by striking the controller's buttons.	Iteration schema: Repeatedly pressing plastic bubbles is metaphorically mapped onto the action of pressing the buttons on game controller.
Engagement	The tactile sense and kinesthetic responses of pressing plastic bubbles engage people in further interactions with the bubble wrap.			
Unexpectedness	Numbers of plastic bubbles installed throughout the bus stop elicit surprising responses.			

Table 4.7 Analysis on Bubble Wrap in Bus Stop

4.3.7 Take a Seat, Make a friend

A large wooden box full of plastic balls was placed on an urban square, where people can go in to sit, talk and make a new friend (Soul Pancake, 2013). The goal is to bring friendship and social relationship back in everyday lives. It enabled strangers to sit in and get to know each another. A sign was posted above the box "Have a Seat & Make a Friend" and passers were invited to sit down with each other and discuss some questions about everyday life that were written on the balls. Example questions include "Seek similar things between the two of you" and "Who has a large influence on your life?" There were 10 relatively large balls in the box containing questions, which remind the people sitting are able to discuss these questions with a complete stranger. This ambient media work was relocated in various places in Brussels where

more random audiences could join the social and bodily interactions with strangers and colorful balls (questions).



Figure 4.7 Take a Seat, Make a friend (Soul Pancake, 2013)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceptual affordances	Emotional affordances	Physical affordances	Intellectual affordances
	Plastic Balls, Wooden Box, Sign can be visually perceived.	The box offering a conversation environment for strangers creates unexpected and warm-hearted experience.	The box full of balls offers possibilities of sitting in, while the balls provide potential actions of picking up.	The question label on the ball elicits thinking about some life and social issues.
Metaphorical meaning making	Visual sensations, Surrounding by balls (Tactile sense)	An audience in this box could share his or her personal experiences that might be unexpected to the other one, which leads to empathetic and touching emotions.	Sitting in the box. Picking up balls.	Container schema: Walking into and sit in the box full of colorful balls metaphorically means being in a new world where people are temporarily separated from reality.
Engagement	The box full of balls indicates the actions of entering and sitting. The sign with text reminds people to enter the box and communicate with each other.			
Unexpectedness	Picking up balls containing various questions brings unexpectedness.			

Table 4.8 Analysis on Take a Seat, Make a friend

4.3.8 Smoking Causes Blindness

This ambient media design was to engage the public's attention to raise awareness that smoking may lead to vision problems (Quit, 2013). It drew upon a common artifact - trash bin as a design element and made the top of the trash bin like a crystal blue eye. When a passerby squeezes a stub on the top of the trash bin, it seems to hurt the eye, which metaphorically delivers the message that smoking causes blindness. The embodied meaning is structured by Counter-force schema.



Figure 4.8 Smoking Causes Blindness (Quit, 2013)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceived affordances Trash bin and designed graph of eye can be visually perceived.	Emotional affordances The large eye burned by the stub could result in anxiety and fear.	Physical affordances The trash bin affords actions of putting out stubs on the top.	Intellectual affordances The behavior of putting out stubs in the eye and the warning text could raise awareness about smoking cessation.
Metaphorical meaning making	Visual sensations (The top of the trash bin is like an eyeball),	Putting out stubs in the eye evokes anxious and terrible emotions.	Putting out stubs on the top of the trash bin.	Counter-force schema: Squeezing a stub on the trash bin metaphorically expresses that

	Tactile sensations			smoking can hurt eyes.
Engagement	The design does not engage people in squeezing stubs on the trash bin.			
Unexpectedness	The eyeball-like trash bin elicits surprise.			

Table 4.9 Analysis on Smoking Causes Blindness

4.3.9 Europe. It's Just Next Door

This ambient media work was created for France's national railway, using doors as a means to promote the railway service and encourage people to travel. The work entitled "Europe, It's Just Next Door" illustrates the slogan by placing digital screens in doors, and then placing those doors in public areas within Paris (TBWA, 2013). Audiences were curious and attracted by the setting, and they opened the doors and subsequently "travelled" to another European city. The colorful doors were labeled with different city names of Europe, and the participants can communicate with someone on the other side of the door. The virtual portals connect participants to those in other cities in real-time, essentially helping them virtually tour and explore other places and participate in local events. The doors are placed in prominent tourist locations and not only connect people to different cities and their attractions, but also the people that reside there. It's an interesting way to not only interact with a new place, but also the locals. For example, when the door is opened, participants are able to interact with a mime artist in Vienna, see a portrait painter drawing for them in Berlin, and dance with a dancer in Amsterdam. Interacting with the doors is metaphorically mapped onto the embodied meaning of travelling to another city, which is structured by Near-Far schema.



Figure 4.9 Europe. It's Just Next Door (TBWA, 2013)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances & Spatiality	Perceived affordances	Emotional affordances	Physical affordances	Intellectual affordances
	The doors on the public spaces can be visually perceived.	The doors elicit curiosity, and the remote scenes in the video on the back of the door bring happiness and unexpectedness.	The doors offer action possibilities of turning over. The real-time video from another city makes audiences to bodily interact with the remote audiences.	All the physical and digital elements enable audiences to have a sense of travelling to another places.
Metaphorical meaning making	Visual sensations, Auditory sensations, and Tactile sensations.	Real time interactions with audiences from another city in the video elicit exciting and lively emotions.	Opening the door and interacting with the real-time video.	Near-Far schema: Interacting with the real-time video behind the door metaphorically denotes that the participant is travelling to

				another European city.
Engagement	The setting of the door engages people in opening it, and the real-time video engages people in interaction.			
Unexpectedness	Doors installed on the public square and the content behind the door bring surprising responses.			

Table 4.10 Analysis on Europe. It's Just Next Door

4.3.10 Revolving Door

The revolving door at the building entrance was designed as ambient media for a ballet School. The picture of a ballet dancer acting with an elegant posture was mounted on the revolving door, and the dancer stood at the center of the door area. As audiences rotate the door, it looks like the dancer is performing ballet. This work engages audiences to interact with the ambient medium in a simple but lively way, which brings both emotional and kinesthetic experience.



Figure 4.10 Revolving Door (Saatchi & Saatchi New York, 2005)

Components	Dimensions of Audience experiences			
	Sensory response	Emotional response	Kinesthetic response	Cognitive response
Affordances &	Perceived affordances	Emotional affordances	Physical affordances	Intellectual affordances

Spatiality	The revolving door at the entrance can be visually perceived.	The interaction with the door brings liveliness and elegance.	The door itself provides action possibilities of rotation.	The interaction with the dancer and the sign on the door exhibit brand personality to the audiences.
Metaphorical meaning making	Visual sensations and Tactile sensations.	The revolving dancer actively elicits lively and enjoyable emotions.	Pushing the handle on the door to rotate the dancer	Cycle schema: Rotating the door simultaneously makes the dancer to perform ballet, which metaphorically denotes liveliness of brand imagery of the ballet school.
Engagement	The picture of ballet dancer mounted on the door engages people in rotating the door.			
Unexpectedness	This design of combining the ballet dancer with the door elicits unexpected experience.			

Table 4.11 Analysis on Revolving Doors

4.4 Discussion on case analysis

This study on ten ambient media works is the first attempt to understand audience experiences in regard to embodied interaction. The connections and differences between embodied interaction and embodied experience need more clarification. In the context of HCI, both terms emphasize the embodied nature in interacting and experiencing with interactive systems. As Section 2.3.4 reviews, “embodied interaction” includes both physical and social aspects in people’s engagement in the world, where people make meaning of it. In Section 2.4.7, “embodied experience” is clarified that people’s experience is grounded in their bodily interaction with physical spaces and objects. However, the two terms have different meanings and uses. “Embodied interaction” refers to the reciprocal actions between audience and ambient media, which means that audiences perform bodily actions upon and perceive sensory feedbacks from ambient media. “embodied experience”

highlights the appraisal from audience whose experience is rooted in bodily engagement with ambient media. This research considers that embodied meaning is a central part in audience experience with ambient media. Audience experience is a holistic concept on the appraisal of four experiential dimensions, while embodied meaning is related to cognitive response to bodily interaction with ambient media.

Based on a relatively general analytical model derived from the theoretical framework, the four dimensions of audience experiences are analyzed in an interpretive paradigm. Despite the subjectivity in analyzing, the results of the analyses show that the theoretical framework is applicable in guiding understanding audience experiences with ambient media. Especially, the embodied meaning is generated from multi-level experience. Based on the ten case analyses, this study contributes to two major findings. First, an audience experience model is built for guiding further studies by synthesizing the interpretive analysis on ambient media works. Second, a typology of ambient media provides preliminary understanding on the relationship between embodied meaning and bodily engagement.

4.4.1 A framework of audience experiences in ambient media

The case analyses indicate that the interaction with ambient media is an active process (see Figure 4.11), in which the audience may perceive the affordances from an ambient medium that could motivate the audience to perform certain bodily actions. The ten ambient media works all involve audiences' bodily engagement and embodied meaning. Combined with other design elements (e.g., visual elements), the bodily interaction with ambient media could give rise to corresponding embodied metaphorical meaning, which is structure by the patterns of an audience's past bodily experiences (embodied schemas). On the other hand, unexpected experience is also elicited in the interaction process.

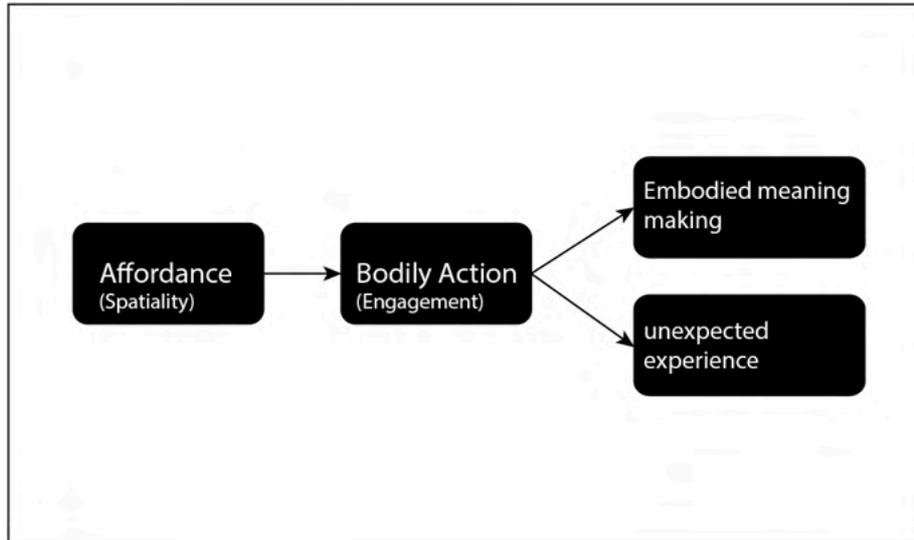


Figure 4.11 Model of audience experiences with ambient media

This model can help to get initial understanding on audience experiences and embodied interactions with ambient media. For instance, in the case of Piano Staircase (see 4.2.3), passersby may notice the visual feature of the staircase that is designed like piano keyboard and provides action possibilities for walking on it (affordance). They may step up or down (bodily actions), which triggers various musical sounds (sensory feedback). Audiences may try to generate various musical pitches by stepping up and down (Scale schema), which metaphorically maps the conceptual structure (musical pitches of piano) on to another structure (heights of stairs). In the meanwhile, the similarity of piano keys and stairs in form constructs a visual metaphor.

4.4.2 Typology of ambient media

As the literature review mentioned, many researchers have made various classifications for ambient media. Shankar and Horton (1999) classify ambient media in terms of their locations, such as retail, leisure, travel and other types. Hutter (2015) uses spatial dimension (2D and 3D) to categorize ambient media. These classifications are merely based on the spatial factors rather than audience experiences or embodied interactions. The research draws on the

model of audience experiences as a basis to build a typology for classification of ambient media (Figure 4.12), where bodily action and embodied meaning stand for the two major considerations on embodied interactions. The horizontal dimension represents the extent to which bodily action is involved, while the vertical dimension is about two types of metaphor.

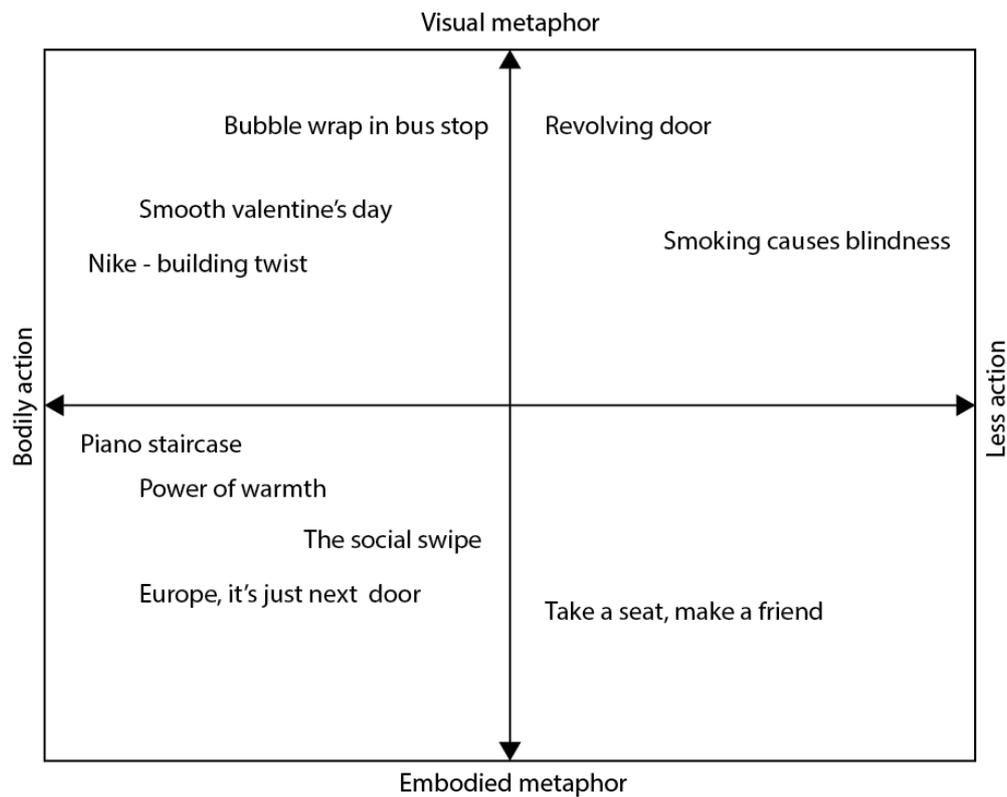


Figure 4.12 A typology of ambient media

Ten ambient media works are classified into four types in terms of this typology. First, bodily actions and embodied metaphors both play a major role in audience experiences with four works (e.g., Piano staircase), which are categorized at the bottom left corner. Although bodily actions are actively involved in the three works at the top left corner, the meaning making largely relies on visual metaphors (e.g., the stems of roses resemble the beard on a face). On the right side, there are less bodily actions involved in audience experiences, while the meaning making in Revolving door and Smoking causes blindness is mainly generated from visual metaphor. For the case Take a seat,

make a friend, Container schema structures the embodied metaphor that maps from sitting in the box onto being in space separated from reality. This typology generally outlines a framework for further investigating the relationship between bodily actions and embodied meaning making in interaction with ambient media.

The case analyses also reflect the concern of passive and active interaction. In active interaction, an audience consciously decides to interact with ambient media, and he is aware of his actions triggering corresponding feedbacks. For example, an audience may intentionally walk on Piano Staircase to make musical effects. In contrast, people sometimes are not aware of the feedbacks resulting from bodily actions, and they are not consciously interacting with an ambient medium. For instance, a passerby may not pay attention to the rotating effect of the picture of a ballet dancer when pushing the revolving door just for passing the entrance.

4.5 Summary

This chapter conducts a range of case analyses for gaining preliminary understanding on audience experiences with ambient media, which is mainly based on the theoretical framework and the researcher's interpretive analysis. The major components of the theoretical framework are organized as experiential factors in the analytical model, which provides a foundation for further investigating the relationship between these various components (e.g., the mechanism of bodily action and embodied meaning making).

Since ambient media to a large extent employs non-verbal and multi-sensory metaphors to elicit embodied interactions, embodied metaphor and visual metaphor are both involved in audience experiences with most cases. Visual metaphor is less generated from bodily actions but rather more about

perception, and it is closely related to perceptual affordance and plays an important role in attracting audience's attention. As the literature review has discussed, there are many interconnections between embodiment, affordances, and experience. In line with the theoretical framework, the findings indicate that the theories of embodiment offer insightful lens for analyzing audience experiences with ambient media. In this research, embodiment mainly refers to two aspects: bodily interaction and embodied metaphorical meaning, which play a dominant role in understanding audience experiences with ambient media. In this regard, further empirical study is needed to substantiate the assumption from the interpretive analysis and support the exploration on embodied interactions.

Chapter 5. Interacting with Piano Staircase²

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5.1 Introduction

In order to further understand audience experiences and develop an approach to designing ambient media, this chapter focuses on conducting an in-depth empirical study to investigate the mechanism between bodily engagement and meaning making in interacting with an ambient media work, and to identify main factors of audience experiences. This chapter first examines a range of criteria for prototyping, and then demonstrates

² Parts of the author's own papers "Tan, L. and Chow, K.K.N. (2017). *Facilitating Meaningful Experience with Ambient Media: An Embodied Engagement Model*. In Proceedings of the Fifth International Symposium of Chinese CHI ACM, Guangzhou, China, 36-46" and "Tan, L. and Chow, K.K.N. (2017). *Piano Staircase: Exploring Movement-based Meaning Making in Interacting with Ambient Media*. In IFIP Conference on Human-Computer Interaction (Interact 2017) Springer, Mumbai, India, 282-291" are included in Chapter 5. Longer sentences, phrases, and paragraphs are referenced.

prototyping process and experience testing for collecting qualitative data that reflects participants' experiences with the prototype. The verbal reports are analyzed, and a coding scheme is formulated in terms of six themes (see Table 5.4). The discussion on the results gives rise to three models (Figure 5.15, 5.16, 5.17) on embodied meaning making and engagement, which offer useful analytical tools and guidance in understanding and designing embodied experience with ambient media.

5.2 Experience tests

The aim of conducting experiments on audience experiences is to collect empirical data for investigating the role of bodily movements in constructing meaning. Based on relevant criteria, a high-fidelity prototype is built as a test bed for experience tests, and the experiment procedures are also demonstrated in detail.

5.2.1 Criteria for prototyping

The criteria of prototyping are aimed to be in line with the three properties of ambient media and embodied meaning making.

5.2.1.1 The scope of spatiality

According to the review on spatiality (see 2.2.4.1), the scope of spatiality for prototyping is mainly concerned with two aspects: the level of public and the scale of space. The illustration (Figure 5.1) identifies the scope for prototyping, which is positioned in a semi-public and human (installation) scale space. The features of elements (e.g., elevator, staircase, door, toilet) of a space are incorporated into ambient media in terms of the interaction possibilities. On the other hand, the prototyping criteria should also consider the convenience and feasibility for conducting experiments. Video recording will be used to record the behavior of audience interacting with the prototype of ambient

media, which requires it should get permission for installing recording device and prototype. The indoor space of Jockey Club Innovation Tower (JCIT) is chosen as the basis for prototyping. The specific setting about prototyping will be discussed in later sections.

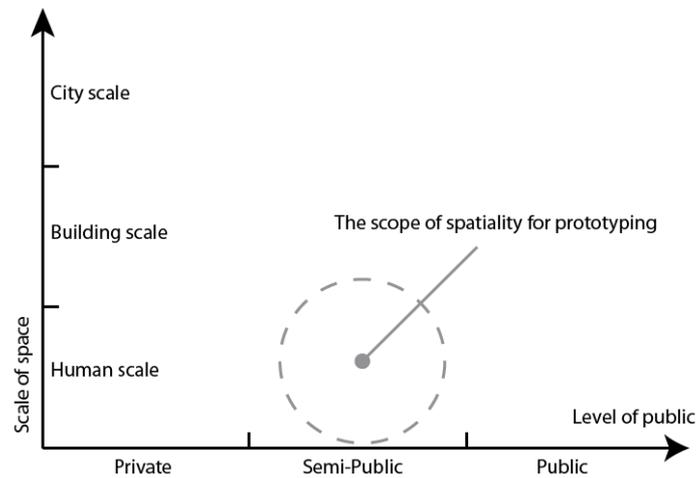


Figure 5.1 The scope of spatiality for prototyping

5.2.1.2 Criteria for unexpectedness

As discussed in section 2.2.4.2, one of the major properties of ambient media is to attract audience’s attention by evoking surprising responses. In regard to the model of schema incongruity (Figure 2.2), the incongruity in experience with ambient media is mainly related to two aspects: unexpected locations and unexpected methods. Location is closely related to the first criterion about spatiality, and ambient media are encountered by audience in unexpected places (e.g., the doors set up on the public square (see 4.3.9)). A study shows that most of ambient media use the strategy of making stimuli stand out from the environment (Hutter, 2015), as passersby in public spaces usually have their prior intentions and may not be easily attracted by surroundings (Jiun-Jhy & Jim, 2015). The second aspect is to amplify audience experiences by using unexpected methods. Based on the literature review and case study, three strategies for triggering surprise are summarized:

- Designing input / output (I/O) relations: When the audience performs an action, the output does not match audience's expectation (e.g., Twisting the shoe results in the distortion of the building (see 4.3.2)).
- Contrasting physical and virtual elements: Digital media is embedded in the physical space, which leads to a mismatch between tangible reality and virtual reality (e.g., After the physical door is opened, digital image emerges to show the scene from another city (see 4.3.9)).
- Mismatching visual contexts: (e.g., The staircase resembling the shape of piano keys elicits a surprise (see 4.3.3)).

The three strategies can be jointly employed to elicit unexpected responses in prototyping.

5.2.1.3 Criteria for engagement

Ambient media design is not just to create new visual and auditory stimuli like traditional media (i.e., poster, TV commercial), and the most prominent feature of ambient media is that it can engage audience's bodily actions by creating physical affordances that can potentially trigger the interaction between audience and environments. In regard to the review on engagement (2.2.4.3), this research is concerned with two aspects of engagement in interaction with ambient media. The first dimension is a temporal model of engagement in terms of I/O relations, which includes two types of engagement: immediate engagement and continuing engagement (Chow, 2010, p. 101). The interaction with *Bubble wrap in bus stop* (4.3.6) is a typical example of immediate engagement, as the action of squeezing is very sudden and the feedback also appears instantly. In the case *The Social Swipe* (see 4.3.5), when the user moves the card along the slot, the animation (e.g., a piece of bread being cut off) plays with the swiping and keeps alive for several seconds, which belongs to continuing engagement. These temporal patterns of engagements provide valuable insights to set up criteria for engagement

with the prototypes of ambient media. On the other hand, bodily engagement can be studied in terms of the scale of bodily actions. There is a growing body of research on bodily movement-based interactions, in which gesture-based movement and whole body movement are used to describe different scale of movement (Antle et al., 2011; Hansen, 2011; Loke & Robertson, 2013). The experiments of both gesture based engagement and whole body engagement aim to involve parts of or full body in embodied interactions and explore the bodily potential in new interactive forms. A prototype for the whole body interaction was developed for understanding of embodied schema through the mapping between participants' full body movement (e.g., running, jumping, dodging) and the real-time auditory feedback (Antle et al., 2009). Bakker et al. (2012) investigated the metaphorical projections between gestural movements (rotating, tapping, squeezing, waving, scratching, shaking) and learning musical concepts. The criteria of engagement for the prototyping are set to meet the continuing engagement and whole body engagement.

5.2.1.4 Criteria for meaning making

Ambient media deliver the message to audience through situated and embodied interactions. The prototype should be linked to a certain message, which could be social issue or a certain brand. For instance, the case (4.3.9) shows that the actions of opening the door and interacting with the real time video signify traveling to another city, which metaphorically express non-verbal message structured by embodied schema (i.e., Near and Far). More importantly, the focus of prototyping is not to evaluate the effectiveness of delivering advertising message but to provide a test bed for exploring the mechanism how embodied metaphors structure audience meaning making in audience experiences with ambient media.

To set up a criterion for meaning making, it needs to look back to the theoretical foundation about embodied metaphor. Based on the metaphor-related insights from cognitive science and interaction design (Antle et al., 2009; Chow, 2013, p 100; Lakoff, 1987, 1992; van Rompay, 2005), this research summarizes two types of embodied metaphorical mappings for generating meaning in interacting with ambient media: visual mapping and conceptual mapping, which are grounded in human sensory perception and bodily engagement with everyday environments. Visual metaphor (see 2.3.2.3) directly links the similar visual feature between two objects, while embodied metaphor bridges a concrete idea (source domain) and an abstract idea (target domain) to make meaning more imaginative. The case *Smoking Causes Blindness* (see 4.3.8) visually projects the sphere shape of trash bin to the shape of eyeball, contributing to a visual metaphor that the audience can immediately understand. *Piano Staircase* (see 4.3.3) comprises both visual metaphor and embodied metaphor. The similarity in shapes of the stairs and piano keys gives rise to a visual mapping which attracts passers' attention. Stepping up and down on the stairs results in instant musical feedbacks, which maps the spatial relation of the stairs onto the musical pitch, and although the spatial relation and musical pitch are different concepts, they are metaphorically combined with audience's bodily engagement. The two types of metaphors also structure the meaning making in the case *The Social Swipe*.

The prototyping is aimed to embed both visual and embodied metaphors in the audience's bodily experience, and to create embodied interactions for imagination and meaning making. The four major factors considered for prototyping are summarized as the following (Table 5.1).

Spatiality	Scale of space	Human scale
		Building scale

		City scale
	Level of public	Private space
		Semi-public space
		Public space
Unexpectedness	I/O relations	
	Physical and virtual elements	
	Mismatching visual contents or contexts	
Bodily Engagement	Scale of action	Whole body engagement
		Gesture-based engagement
	Temporal pattern	Immediate engagement
		Continuing engagement
Meaning Making	Visual mapping	
	Conceptual mapping	

Table 5.1 Variables of ambient media design

5.2.2 Experience prototyping

Regarding the criteria of prototyping, this study aims to recreate a high-fidelity prototype of ambient media for audience experience test and empirical data collection, and *Piano Staircase* (4.3.3) was chosen as a reference for the prototype. Firstly, this section reviews the relevant studies on piano staircase, which provide worthwhile references to the prototyping.

5.2.2.1 Related studies on piano staircase

Based on Piano Staircase, Peeters et al. (2013) designed Social Stairs to investigate people's behaviors in public space and social interaction. People co-created musical effects, when walking on Social Stairs, and their friends were subsequently invited to play with the stairs. They can collectively and constantly explore the interaction with Social Stairs. A method Experiential Design Landscape was proposed to design toward people's long-term structural behavioral change.

Some studies on gamification also mentioned Piano Staircase. Kankanhalli et al. (2012) drew upon Piano Staircase as a case to demonstrate gamification can lead to people's behavior change by using game elements in non-game environments. According to Asquer & Krachkovskaya (2015), Piano Staircase embodies the main features of gamification, and the everyday activity becomes a game-like interaction between people and the staircase. Khan (2012) built an interactive musical staircase to enhance rehabilitation therapies for children. The experimental findings indicate that the piano staircase can actively motivate participants to physically climb it, and therapeutic performance was significantly improved after therapy sessions. In short, the original work of Piano Staircase was adapted or discussed for people's positive and active engagement.

5.2.2.2 Making the prototype

Experience prototyping is a type of prototyping that can help designers and users to get real experience in a simulated situation by directly interacting with the prototype (Buchenau & Suri, 2000). The objectives of employing experience prototyping are embodied in three aspects: understanding a certain condition and context, developing and actualizing design ideas, and facilitating the communication between designers and participants. The forms of prototype include both low-fidelity mockup and high-fidelity interactive installation embedded with spatial elements. Prototyping is a unique means to create possibilities for understanding how people actually experience a situation by viewing, touching, hearing, even smelling and tasting various attributes of an artifact such as materials, graphics, shapes, spatial relations (Koskinen et al., 2011, pp. 134-136).

The stair space of the third floor in Jokey Club Innovation Tower at the Hong Kong Polytechnic University (see Figure 5.2) was employed as the physical basis for building prototype, as this space is in line with the criteria of semi-

public and human scale space for prototyping (criteria of spatiality). The piano staircase resembles the shape of piano keys (mismatching visual elements as one criterion of unexpectedness). The whole bodily actions (criteria of engagement) trigger auditory effects (contrasting I/O relations as one criterion of unexpectedness), and the bodily interaction with the physical space (stair levels) metaphorically conveys musical concepts (e.g., the level of pitch). This study is expected to provide empirical evidence to support the interpretive analyses in the previous chapter.



Figure 5.2 Staircase in Jockey Club Innovation Tower

In order to actualize this ambient media work, two aspects of the implementation need to be considered: physical computing and auditory outputs. The system structure is shown as a diagram (Figure 5.3). First, the audience's attention is attracted by the piano staircase to step on it, and the pressure of stepping is sensed by the sensors embedded in the stairs. The signal from sensors is transferred to Arduino (Arduino, 2016) where a unique value for each sensor is produced and sent to the programming on MacBook. Processing (Fry & Reas, 2016) is used to generate musical signals in terms of

the values from Arduino, and every value corresponds to a certain note of the piano key. As there are 15 stairs, two octaves (Figure 5.4) are included to match the number of the stairs.

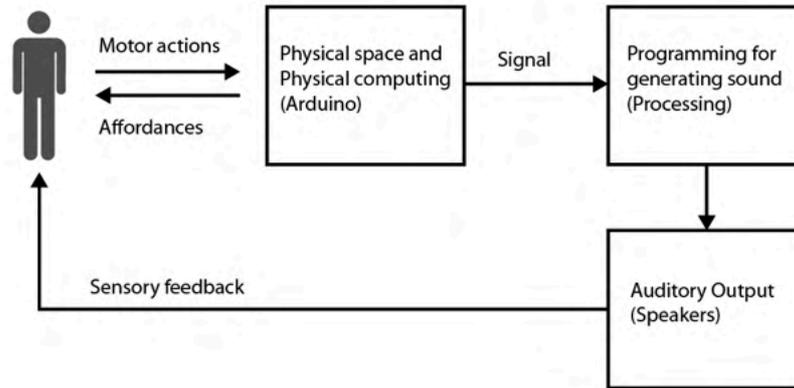


Figure 5.3 Prototype structure of Piano Staircase

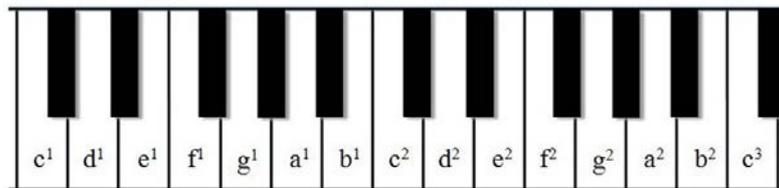


Figure 5.4 Fifteen notes

The library “Minim” in Processing is used to output interactive audio (Figure 5.5). 15 audio clips corresponding to 15 notes are loaded to play once Processing receives values from Arduino (Figure 5.6). The serial protocol makes the communication between Processing and Arduino available, and the Serial library in Processing can recognize and output data from external microcontroller devices (e.g., Arduino).

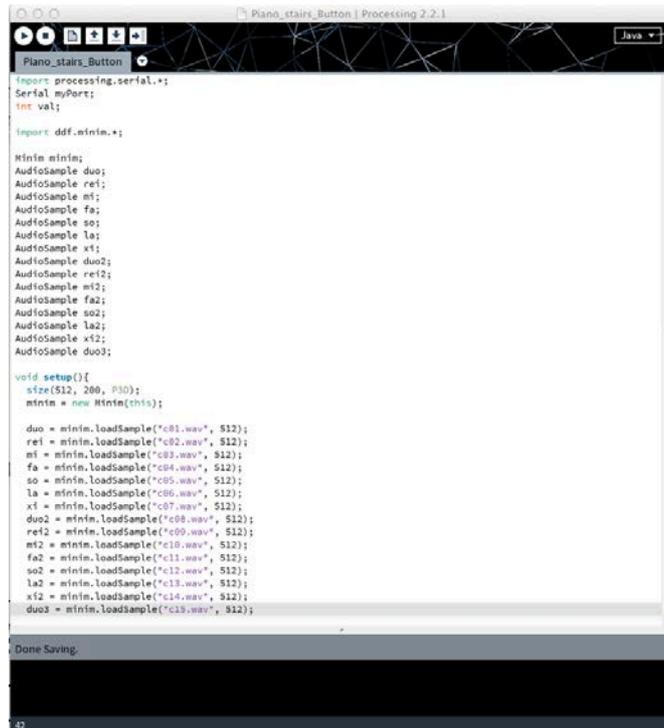


Figure 5.5 Coding in Processing IDE

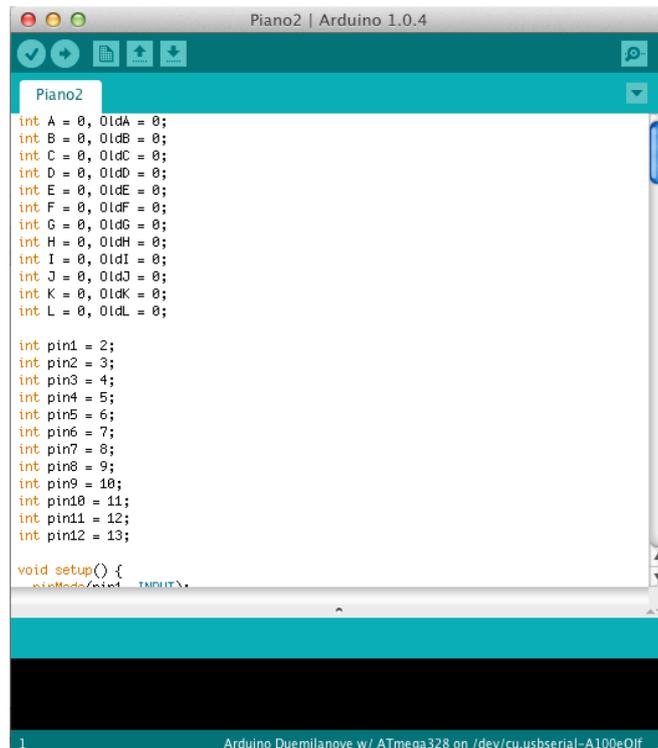


Figure 5.6 Coding in Arduino IDE

Pressure-Sensitive Conductive Sheet or Velostat (Figure 5.7) is used as a material for making pressure sensor connected to Arduino. The major

property of Velostat is electrically conductive, and its electrical conductivity increases when pressure on it is applied.



Figure 5.7 Pressure-Sensitive Conductive Sheet

5.2.3 Participants and procedure

After completing experience prototyping, audience experience tests were conducted with participants ($n = 30$; 13 males and 17 females) experiencing the Piano Staircase. Twenty one of them were aged between 18 and 25, seven were aged between 25 and 30, and two were above 30 years old. Twenty two were from Hong Kong, seven from Mainland China, one Indian. Most participants were recruited, prior to the test, from a university campus in Hong Kong except for three passers randomly invited at site.

The whole experiment comprised of three sessions. First of all, participants were informed that they can feel free to experience a physical space without time limitation, and they can choose to quit the test at any time. A consent form (Appendix 1) was signed by them. In the free experience session, participants can step up or down, jump, run, stride, stamp and stay on the staircase. The behaviors of participant were videotaped by a small and well hidden camera, which was intended to eliminate participant' psychological burden, although they were informed in advance that the researcher would videotape their experience process before tests. The video data can be used for further video-based data analysis. Each participant interacted with the

work for 3-6 minutes, and the duration depended on their own intention. After the free play session, each participant was immediately involved in a face to face interview in a meeting room. The semi-structured interview questions (Table 5.2) were based on the theoretical framework and designed to elicit participant' verbal reports about their feeling and thinking. The video recording behaviors of participants was shown during the interview to help them recall their experience. The dialogues between researchers and participants were recorded as audio data for qualitative analysis.

Components of theoretical framework	Questions
Sensory responses, affordances	1. Can you describe the first impression of this staircase?
Bodily, sensory responses, unexpectedness	2. Please describe your feeling when you walked on the stairs.
Embodied schema and metaphor	3. Can you talk about how you feel and think when hearing the musical sound?
Cognitive experience, conceptual mapping	4. Can you talk more about the stairs and the music?
Bodily and cognitive responses	5. What is overall feeling about this staircase? (Why do you have this feeling? What is the feeling about your body?)
Emotional response Cognitive experience	6. Can you recall anything in your everyday life or imagine something while using the staircase? What did you do in that scenario?
Engagement	7. If you pass by the staircase, do you think it will attract you to step up or down?
Metaphorical imagination	8. If this installation is sponsored by a brand, what do you think it could be? (Why do you have this association?)

Table 5.2 Interview questions

5.3 Data analysis

Two types of data were produced in the experience tests: the video data recording the participant' behaviors and the retrospective verbal report. This study focused on analyzing the verbal data that reflected the participant's

primary experience, while video recording provided information about observational bodily movements and behaviors. The audio records of interviews were transcribed as text files. The researchers conducted thematic analysis to search, identify, analyze, and interpret the themes related to embodied audience experiences and their interrelations within the transcribed verbal report. The interview transcripts of 30 participants were imported into the qualitative analysis software HyperResearch (Figure 5.8) for coding and organizing themes.

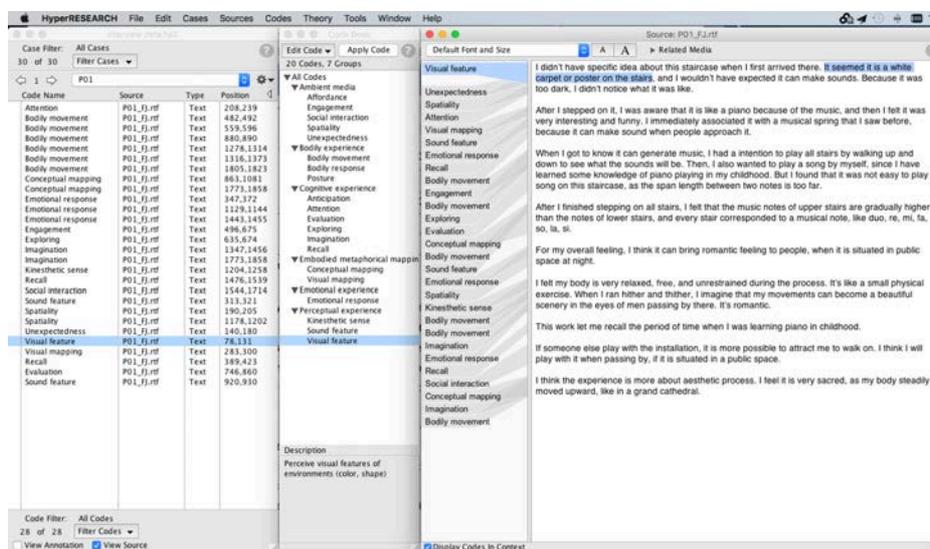


Figure 5.8 The interface of HyperResearch

The process of thematic analysis integrated inductive with deductive approaches (Fereday & Muir-Cochrane, 2006) to complement the existing research framework by developing themes direct from the data and applying a prior code template (Table 5.3) to organize text data. The template was formulated based on the theoretical framework and the research question. The coding process included three phases. First, the researchers read the transcripts repeatedly to be familiar with all verbal data. Writing notes and marking key words were used to explore potential meanings and patterns. Then, codes from the prior code template were assigned to segments. The phrases or sentences related to the nine codes were initially labeled in the

coding book, and the meaning of each code was also described (e.g., the code “engagement” is described: the participant was physically or mentally engaged in interaction with the work). The second phase was to develop inductive codes rooted in verbal data regardless of the prior template. These inductive codes evolved with the coding progress. Once a new code was initially defined, the researchers went back to check the previous transcripts (cases) for coding for possible segments. The segments labeled with same code were compared and across all cases for some refinements. Finally, after all cases were coded, they were reexamined, compared, and grouped for identifying themes based on the theoretical framework.

Ambient media	Engagement
	Spatiality
	Unexpectedness
Audience experiences	Sensory experience
	Emotional experience
	Kinesthetic experience
	Cognitive experience
Embodied metaphorical mapping	Visual mapping
	Conceptual mapping

Table 5.3 The prior coding template

The final coding scheme (Table 5.4) includes six themes of ambient media, bodily experience, cognitive experience, emotional experience, embodied metaphorical mapping, and perception. Twenty codes were identified and defined for further analyzing participant’s embodied experience and engagement patterns.

Themes and codes	Descriptions
Perceptual experience	
Forceful feedback	Movement-based tactile sensations of the environment (hard, soft, elasticity)

Sound feature	Perceive the properties of changes of sound (tone, volume, pitch)
Visual feature	Perceive visual features of environments (color, shape)
Kinesthetic experience	
Bodily movement	Observed and described bodily movements
Kinesthetic sense	Perceive the positions, states, movements of the body parts (fast, slow, fluent)
Posture	Stay in a posture for a while
Metaphorical mapping	
Embodied mapping	Project bodily interaction on to other concepts or expressions
Visual mapping	Project one object on to another object in terms of the visual similarity
Cognitive experience	
Anticipation	Expect a certain feedback or result before acting
Attention	Mentally concentrate on something or somebody
Evaluation	Make an appraisal of participant's experience or compare it with other things
Exploring	Intentions and actions to explore the work or create sound effects
Imagination	Associate the experience with other scenarios or concepts
Recall	Remember the past experience and environments
Emotional experience	
Emotional response	Describe emotional experience
Ambient media	
Affordance	The features of environment that can elicit potential bodily actions
Engagement	Being physically or mentally engaged in interaction with the work
Social interaction	Mention co-experience other participants when interacting with the work
Spatiality	Describe spatial features or relations
Unexpectedness	Feel unexpected or surprised during interaction process

Table 5.4 Coding scheme

5.4 Results

The coding scheme provides possibilities for discovering the underlying patterns of embodied interactions with ambient media. This section focuses on presenting the qualitative results about the six themes based on the embodied interaction framework.

5.4.1 Perceptual experience

All participants started to experience the Piano Staircase (PS) with their perceptual responses. Figure 5.9 shows that the participants (Figure 5.9a, c, d) got their initial impression through visual perceptions, while some passers (potential participants) were attracted by the participant's engagement and they perceived PS with both visual and auditory responses (Figure 5.9b).

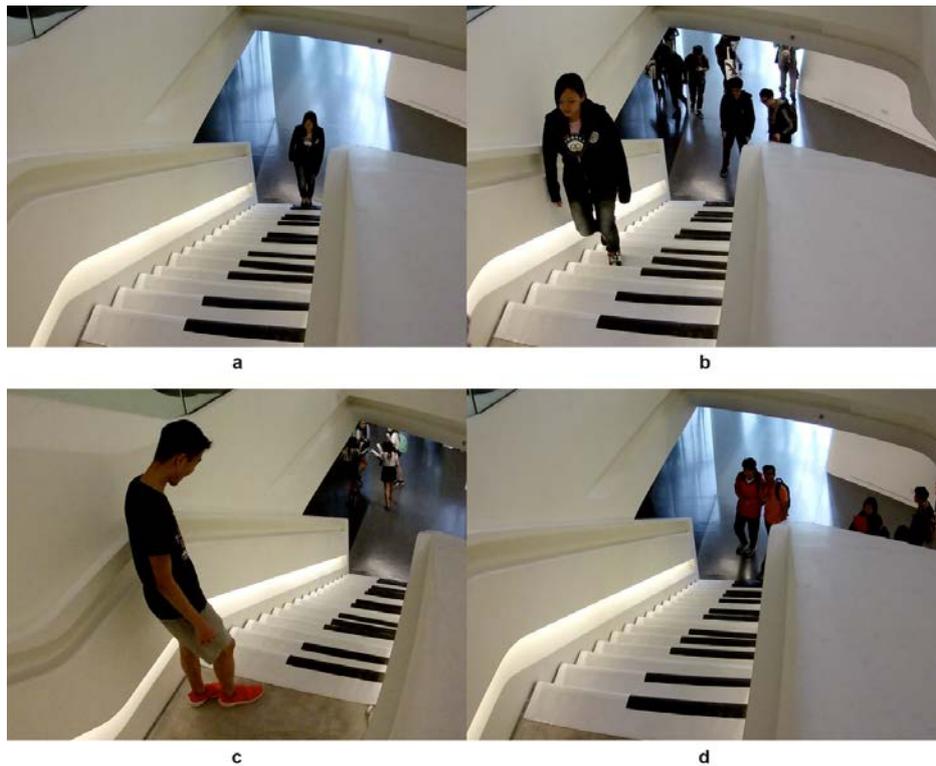


Figure 5.9 First impression

27 out of 30 participants said they first noticed the white and black colors on stairs, while other three participants were attracted by musical sounds before seeing the staircase. When being asked their feelings about stepping on PS in

the beginning, 20 participants mentioned they felt surprised to hear the music sounds. Two participants (P2, P14) said the musical sounds were very realistic and like the sounds made by real piano. All participants noticed the features of music changing during the interaction process, such as pitch, rhythm, duration and continuity. Many participants talked about their kinesthetic feelings when moving on PS. For example, P2 mentioned “It’s fast and fluent when I was walking down from the top.” and “feeling of gravity of my body”. P5 said “It’s a little hard stepping on the stairs.”

5.4.2 Kinesthetic experience

Although the interview questions did not directly ask participants to talk about their bodily movements, all participants described their primary experience related to various actions, speed, force. The most frequent code (Figure 5.10) is “Bodily Movement” with 75 times (M = 2.5). Many participants also described their bodily states during imagining and recalling.

Code	Total	Mean	Std Dev	Bar Graph
Bodily movement	75	2.5	1.383	
Conceptual mapping	57	1.9	0.803	
Emotional response	41	1.367	0.809	
Exploring	37	1.233	0.774	
Imagination	34	1.133	0.629	
Kinesthetic sense	34	1.133	0.937	
Engagement	31	1.033	0.669	
Visual mapping	30	1	0.263	
Sound feature	27	0.9	0.662	
Visual feature	22	0.733	0.521	
Anticipation	21	0.7	0.596	
Evaluation	20	0.667	0.844	
Unexpectedness	20	0.667	0.547	
Affordance	18	0.6	0.563	
Bodily response	16	0.533	0.507	
Spatiality	12	0.4	0.77	
Attention	9	0.3	0.466	
Posture	9	0.3	0.466	
Recall	9	0.3	0.596	
Social interaction	7	0.233	0.43	

Figure 5.10 Frequency of Codes

Different actions

Many participants tried different actions (e.g., Figure 5.11: stride (a), jump (b), run (c), stamp (d)) rather than just stepping. Five participants skipped over one or two stair(s) by taking a long stride. P10 mentioned “Sometimes I

skipped one stair to try new mode to seek different sound effects.” Seven participants said they tried to play a song by jumping from one stair to another. Four participants (P3, P9, P11, P24) stamped feet on one stair for trying to make music last longer or repeated.



Figure 5.11 Different Actions

Force and energy

Eight participants said they felt slightly tired when walking upward and had to exert more power to step up than step down. Twelve participants mentioned they walked fast and easily from upper stairs to lower stairs, while walked slow and consumed more energy. For instance, P10 and P30 said they felt very smooth and light when going down. Four participants (P7, P10, P12, P22) compared playing music on staircase with playing piano by hands. P22 said playing music through body was a novel experience, and the whole body was engaged and full of energy. P12 mentioned the force of moving body was stronger than moving fingers.

Posture

Some participants stayed on the staircase for a while or keep in a posture, such as opening both arms for balance and keeping in a posture like standing. Figure 5.12 shows that two participants stood for a moment during interaction process.



Figure 5.12 Posture

5.4.3 Embodied metaphorical mapping

Visual Mapping

When the researcher asked participants about their first impression of the staircase, all participants immediately associated the staircase with piano. They felt it was like a piano in shape and color: “I can recognize the staircase was like a piano keyboard” (P2). “Before I stepped on it, I supposed it was like a piano and it could make sound” (P5). “It looks like a piano keyboard, but I didn’t know it can make sound” (P11). “The white and black patterns on the staircase look like a piano” (P17).

Conceptual Mapping

Pitch (high, low) and spatial level: After a period of adapting to the work (walking up and down), most of the participants had a mapping between musical pitches and levels of stairs. For example, when being asked what feelings they about the music, P3 said: “After I heard the first sound, I wanted to walk up following the stairs. Then I also found it had a pattern like a

spectrum of notes of keyboard.” P10 described: “I felt that the music notes of upper stairs are gradually higher than the notes of lower stairs, and every stair corresponded to a musical note, like duo, re, mi, fa, so, la, xi.”

Tempo (fast, slow) and speed of movement: Four participants (P4, P11, P16, P28) described that they experienced the changes of tempos when walking at different speeds. A participant (P11) mentioned she felt the music became slower when walking up than down. P28 said he generated a fast tempo of the musical sounds when stepping fast.

Flow (fluent, jagged) and speed of movement: The analysis shows participants had a mapping of the speed of movement and psychological fluency. Some participants mentioned that they walked fast or slow in two directions (up or down). P4 said: “It was more fluent and relaxed when walking down from the upper stairs, as I can walk faster.” P8 mentioned he intended to walk on all stairs very quickly to experience a smooth feeling. One participant (P28) described his fast movement was like a waterfall which was very fluent and smooth. In contrast, P23 said walking up on the stairs was slow and she felt laborious and stiff.

Force (heavy, light) and orientation of movement: Some participants experienced a sense of force when walking in different directions. The mentioned words include “heavy” (P2, P11), “intense” (P2, P12), “relaxed” (P1, P4, P7, P15, P23, P26, P28), “unconstrained” (P1), “light” (07, P9, P11, p28), “subside” (P29). Many participants said they felt relaxed or light when walking downward, as they exerted less energy or force when being dragged by gravity. P28 compared the force of walking down to a waterfall. However, a few participants had a reverse feeling: “I felt very relaxed and fluent when walking upward, but it gradually became deep and heavy when walking down” (P2). “I had a feeling of gravity of my body when walking down, and it was more

intense moving my body on stairs. The feeling of force is stronger...” (P24). P29 felt she was subsiding when going down.

Apart from the above abstract concepts, many participants also projected the experience with PS onto some physical objects and concrete brands. For the question what brand can be associated with the experience of PS, the most direct mapping was music-related brands (e.g., Yamaha (P4)). In addition, some participants also mapped their bodily movements onto physical exercise, sports brands, cathedral (P1) and waterfall (P28).

5.4.4 Cognitive experience

Attention and Evaluation

Before starting stepping on PS, almost all participants indicated their attention was caught by the white and black design of the staircase, as the color contrast was distinct from the grey staircase. After they started to walk on PS, their focus was on the musical sounds triggered by their stepping. Two participants (P7, P25) mentioned they also noticed the black area of the stair and tried to make different sound effects by stepping on it. Some participants paid attention on the changing of rhythm and pitch during the interaction process.

Many participants constantly evaluated the interactive experience at different moments. Four participants (P7, P9, P14, P24) mentioned that the distance between two stairs (e.g., the first and the fourth) were too far, and they cannot reach it through stretching legs to generate a tune or chord. Two participants (P5, P7) felt the feedback of stepping was too hard, as they can feel a force of rebound after pressing keys on real piano. Some participants (P4, P8, P10, P22, P27) emphasized that it was a novel and different experience to walk on PS, and the overall feeling was active. “Previously walking on stairs was very boring, but this music staircase is dynamic and

interesting” (P27). P28 said walking on this staircase made her feel relaxed and it can change people’s behaviors and attitudes toward positive direction.

Anticipation and Exploring

Some participants, who declared they had some piano performance skill, had an intention to play a music composition or a little tune through interacting with PS. For example, P3 mentioned “I can play piano, so when I saw this piano staircase I really want to play a composition on it. I would like to play this for my friends.” Apart from playing compositions, two participants (P8, P9) intended to step on all the stairs one by one and to see the musical effects. P9 described “After I initially stepped on it, I suddenly heard the music, and I wanted to play all the keys and to see whether the notes sequentially match each stair.” Two participants (P9, P26) mentioned they expected the stairs can have some lighting effects when the musical sound was simultaneously triggered. P5 and P7 want to perceive the elasticity of stairs after leaving their feet from stairs like the piano keys bouncing up. Three participants (P10, P23, P27) mentioned they would like to play PS with other people rather than individually walk there.

A few participants (P7, P8, P11) mentioned, after started stepping on PS in the beginning, they immediately tried to experience all stairs one by one to seek what would happen. P7 described: “after I stepped on it, I had an intention to play all stairs by walking up and down to see whether it included all piano notes.” After adapting to the musical sounds, P7 deliberately stepped on the black keys for seeking different feedbacks. Some participants (P2, P8, P18, P23) changed their walking speed, when stepping on different stairs, to generate new music feedbacks. P19 said: “I tried to generate longer musical sound by staying on one stair for a while.” Four participants (P2, P8, P10, P19) also explored different movement patterns by performing different actions. As

shown in Figure 5.13, the participant jumped, strode, and ran on stairs to generate various musical effects.



Figure 5.13 Exploring

Recall and Imagination

Some participants mentioned interacting with PS recalled the environments that they experienced in the past. For example, P01 said: “I immediately associated it with a musical spring that I saw before, because it can make sound when people approach it.” P06 described: “After I stepped on it, I felt it was like in a hotel hall, as I previously heard the music of piano played by someone when I walked on the stairs in hotel.” Two participants (P7, P9) recalled a traditional children’s game named “house-jumping” that they played in childhood. P9 also mentioned she had seen a similar work in a shopping mall. P18 remembered a scenario of fairground in an animation movie where a staircase can make musical sounds.

Although PS was directly associated with musical instruments by many participants, they also got different imaginations about other scenarios and concepts. For instance, P01 thought the walking experience was very sacred, as her body steadily moved upward, like being in a grand cathedral. P4 imagined that he was situated on a ladder in the sky and the body was fluttering with the musical changes. Other imagined spaces and objects include a shopping center (P25), a jewelry brand (e.g., Swarovski) (P10), and waterfall (P28). P10 thought the generated sounds were like the pearls or

crystals dropping into a metal plate, and P28 described fast walking downward was very smooth, like a waterfall.

When being asked about what brands could be associated with PS and their imaginations on the current experience, many participants (P3, P5, P7, P11, P12, P14, P26, P29) mentioned physical exercises and sports brands. For example, “I think it is related to fitness and physical exercise. Nowadays people usually sit in office for a long time, and if this piano staircase is set up near the office, people are likely to have more opportunities to do exercise with it” (P3). “In my first impression, it is directly related to music brand. Also, I can think of sports brand, as it engaged people in doing bodily exercise” (P7). Two participants (P11, P29) mentioned specific brands about scooter and sneaker. Three participants (P8, P23, P28) also related it to raising awareness of health.

5.4.5 Emotional experience

Most of the participants described the overall experience was positive (interesting, happy, fun, exciting, pleasing). For example, P1 said: “It was very interesting and funny, and I think it can bring romantic feeling to me.” Four participants (P3, P8, P10, P24) mentioned it was playable and fun. Furthermore, three participants (P5, P12, P19) felt that the higher pitches made them more excited. In contrast, two participants described their feeling gradually became deep and heavy when walking down (P2, P11). P9 intended to walk down fast to experience the feeling of fast tempo which made her pleased.

5.4.6 Ambient media

Affordance

All participants can perceive the sensory affordances (visual design of PS and musical sounds), and most of the participants noticed the staircase’s visual

features, while a few participants were attracted by the musical sounds. During the interaction process, the changes of notes on stairs motivated participants to perform different potential actions. The black area on staircase also solicited a few participants deliberately stepping on, although it did not generate any feedback. The physical setting of the staircase afforded the possibility of bodily movements for participants.

Unexpectedness and Engagement

Unexpectedness occurred not only in the beginning but also in the whole process of interaction. Many participants felt surprised to hear the musical sounds when they first stepped on the staircase, as they could not expect the musical feedback in advance. For example, P1 said: "After I stepped on it for the first time, I was really surprised by the sound." Although some participants, who had seen other participants' performing before they stepped on, did not feel much unexpectedness in the beginning of experience, they described various unexpected feedbacks through shifting different movement patterns. P8 said the generated new musical effects on the staircase made him excited. P19 strode over and stamped on stairs to trigger new musical sounds that he would not expect.

The engagement with PS includes both bodily and cognitive dimensions. Many participants mentioned how their perceptions and bodily states affected their future intentions, and their cognitive states also determined further actions. For example, a participant (P19) mentioned he wanted to make the sound last longer and stayed on a stair for a while. P4 mentioned she move her whole body to produce music, and energy was engaged with it. She was trying to make different music by stepping on different stairs rather than following the order of stairs. P8 had an intention to play all stairs by walking up and down to see whether it included all piano notes. P2 wanted to try different pattern on the staircase. P10 felt very fluent and smooth when

going down, and I was to sound out what pattern of it when going up. As engagement is related to all aspects of audience experiences, we will elaborate the factors of engagement in discussion section.

Spatiality and Social Interaction

A few participants had a sense of public space when they experienced with PS. They recalled environments they had experienced before. For example, P6 mentioned a hotel hall where she heard the music of piano played by someone walking on the stairs in the hotel. P2 recalled a subway station where he saw a similar work. P9 also remembered a similar work in a shopping mall. On the other hands, many participants noticed the physical spatial features. Four participants (P3, P8, P10) mentioned the spatial relation of stairs. P3 described: "It became a dynamic thing from a flat surface. I noticed the pitch went up with the height of the stairs." P8 said: "The keys were distributed on different levels rather than a flat surface." P10 mentioned it seemed that the piano keys were distributed on vertical levels.

Four participants (P3, P11, P23, P27) felt they would like to play with other people rather than alone. As shown in Figure 5.14, the participants talked with each other (right) and one participant smiled to another (left). P23 said: "When there was another person on the staircase, we played music simultaneously and it was funnier. P27 hoped more people played this together and they can generate more dynamic effects. P3 wanted to share her performing with her friends. One participant (P13) asked another person to take photos for her, and she said it would be fun to post it on Facebook.



Figure 5.14 Social interaction

5.5 Discussion

5.5.1 Bodily Movement-Based Meaning Making

The qualitative analysis shows the participant's bodily movements are closely correlated to embodied metaphorical mappings and cognitive experience. Based on the results of data analysis, this section focuses on analyzing the relationship between bodily experience, metaphorical mapping, and cognitive experience, and other related studies are compared.

Embodied conceptual mapping

Our findings show that conceptual mapping can be activated by the audience's immediate bodily movements. This supports and extends the idea that the embodied metaphor projects a concept of source domain (embodied schema-based) onto a concept of target domain (abstract) (Antle et al., 2009; Lakoff, 1992; Wilson & Gibbs, 2007). A range of conceptual mappings (Table 5.5) are elicited by bodily states (e.g., speed of movement). The bodily movements (walking upward or downward, walking fast or slow, walking higher and lower) speed up a projection from bodily experience to the abstract and intangible concepts (pitch, tempo, flow, and force). Different from the purely cognitive processing of metaphorical mapping (concept-to-

concept) in linguistics and cognitive science, the conceptual metaphor in the interaction with ambient media maps the features of primary bodily experience (source domain) onto the abstract concept (target domain).

Features of movement	Metaphorical concepts	Mappings
Spatial level (high, low)	Pitch (high, low)	High level - High pitch Low level - Low pitch
Speed (fast, slow)	Tempo (fast, slow)	Fast movement - Fast tempo Slow movement - Slow tempo
Speed (fast, slow)	Flow (fluent, jagged)	Fast movement - Fluent Slow movement - jagged
Orientation (up, down)	Force intensity (heavy, light)	Up - Heavy (Intense) Down - Light (Relaxed)

Table 5.5 Embodied conceptual mappings

The studies of Antle et al. (2009, 2011) show that the mapping between the input of physical bodily actions and auditory output can lead to intuitively comprehending abstract concepts. The participants needed to finish a series of structured tasks, and the metaphorical concepts were prepared prior to the experiment by researchers. Compared with these procedures, our study does not have a structured task, the conceptual mappings were directly elicited from lively bodily interactions with PS. Thus, we propose embodied interactions with ambient media is a process of meaning-generating rather than mere meaning-understanding.

Embodied schema-structured metaphor

The experimental data provides new empirical evidence that is consistent with the idea of embodied schema-based product expressions (Hurtienne & Israel, 2007; Van Rompay et al., 2005; Wilson & Gibbs, 2007). The quantitative results (Van Rompay, 2005) partly prove that the understanding of visual expression of products is rooted in embodied schemas which are based on a

series of spatial relations (e.g., In-Out, Size, Front-Back). Moreover, Johnson (1987) also examine those gestalts which embodies more internal structures of bodily experience (forceful interaction). Seven force-related schemas (e.g., Compulsion, Attraction) are demonstrated to play an important role in constructing meaning. Based on the data analysis on bodily experience, we propose a part of conceptual mappings are grounded in these force-related schemas, as the mappings of flow and force intensity are less structured by spatial relations rather closely tied to forceful experience.

The first two mappings (Table 5.5) are based on the same schema Scale, as High-Low and Fast-Slow are more about a cumulative character and dependent on the spatial and orientational factors. However, in the other two mappings (Fluent-Jagged and Heavy-Light), many force-related words (heavy, intense, relaxed, unconstrained, light, subside) mentioned by the participants mutually are related to the body's forceful interaction with the space and kinesthetic experience. The mapping from bodily movements to fluency is extended from the schema Gravitation which is defined as an experiential structure that the body is physically dragged toward the earth. Especially, one participant described her kinesthetic feeling about fluent moving of a waterfall, which is a typical Gravitation-based mapping. The mapping of bodily movements and force intensity is structured by Removal of restraint that is exerting a force (heavy) to remove a barrier and the barrier is removed (light or relaxed). This is in accord with several qualities of force gestalts: vector, path of motion, degrees of force intensity. We believe that force-related (kinesthetic) schemas are overlooked by the research on embodied interaction, and further exploration is needed.

Embodied schema-based imagination

The findings indicate that the embodied conceptual mapping not only elicits immediate concept generating and understanding, but also triggers further

cognitive processing such as imagination and recall. This study also believes that the participant's imagination is also grounded in the recurrent patterns (embodied schematic structures) of people's past perceptions and actions. The qualitative data shows that participants associated the experience with different objects (e.g., ladder, scooter) or environments (e.g., cathedral, hotel). As previously discussed, these elicited imaginations also can be summarized as two types of schemas: orientation-related and force-related. Entailed by upward movements on stairs, two participants imagine that being a cathedral and being on a ladder. For the cathedral case, the participant maps her feeling of upward movement onto a holy imagery, which forms a metaphorical concept (abstract) "Holy is up". This abstract concept then is mapped onto an imagined cathedral (concrete). This mapping of imagination is typically organized by an orientational or vertical relation: Up - Down or Verticality schema. The second type of imaginations is tied to the participant's forceful bodily experience with PS. The mentioned tangible objects and environments include sneaker, scooter, waterfall, house-jumping, and jewelry, these are related to the force-related movements. The imagination of sports products (sneaker, scooter) results from participants' past kinesthetic experience (run, ride, sliding), in which immediate bodily experience is linked to an image structure (Compulsion) formed from the long term memory. The other three mappings also arise from the participant's forceful experience with gravity and kinesthetic sensations:

- 1) The schema for the mapping of stamping on the stairs and a jewel dropping to a metal plate is Blockage.
- 2) The schema for the mapping of fast walking down and waterfall is Gravitation.
- 3) The schema for the mapping of bodily movements and the game house-jumping is Enablement.

Based on the empirical findings of this study and previous studies (Antle et al., 2009; Van Rompay et al., 2005; Wilson & Gibbs, 2007), we summarize a model (Figure 5.15) to demonstrate the process of bodily movement-based meaning making. Past long term perceptual and motor experience form various relational patterns (spatial and forceful relations) that can be pervasively extended to construct different meanings (Line 1). People's bodily interactions can activate the conceptual mapping from immediate bodily experience (e.g., moving fast) onto an abstract concept (e.g., fluent) (Line 2), which results in an embodied metaphor structured by an embodied schema (Line 3). Embodied metaphors also can facilitate further imaginations related to imagined environments, brands, and objects (products) (Line 4). Embodied metaphor and embodied imagination are both elicited by bodily movements (Line 5) and structured by embodied schema (Line 6). They share similar mapping process, but normally embodied metaphor is a mapping from a concrete physical experience (action and perception) to an abstract experiential concept, and embodied imagination sometimes maps an abstract concept onto an imagined concrete environment or object (e.g., holy - cathedral, fluent - waterfall).

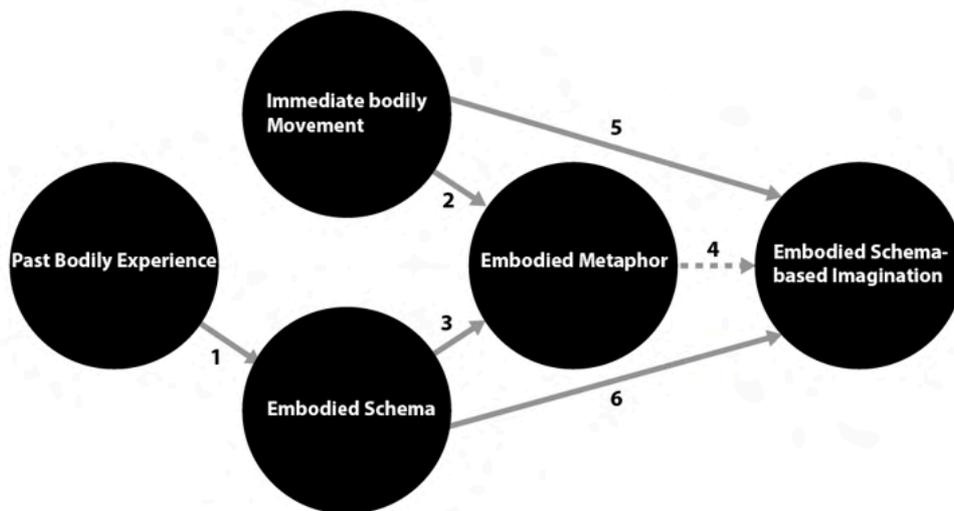


Figure 5.15 Embodied meaning making model

5.5.2 Embodied engagement for audience experiences

This study develops an embodied engagement model (Figure 5.16) to investigate meaningful audience experiences with ambient media. This model integrates interaction process (temporal dimension) with affordance-based experience: The horizontal dimension represents a temporal interaction process comprising initial encounter, adaption, anticipation, exploration, and evaluation in which audience experiences evolve through the whole process; the vertical dimension refers to four types of responses (sensory, physical, cognitive, emotional) which are based on four types of affordances (see 2.5). Our findings show that the capability of engaging audience depends on the extent to which the work provide affordances to drive embodied interactions between the participant and the ambient media work. Each type of affordances has various roles and intensity levels in different interaction phases. Three levels of intensity (high, medium, low) with three values of brightness stand for the major or minor effect of an affordance on experience.

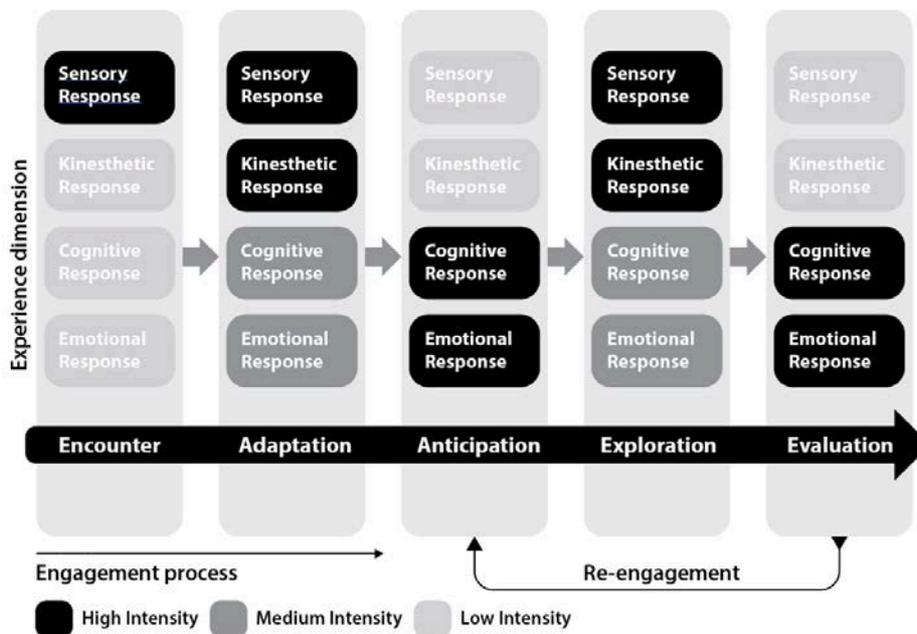


Figure 5.16 Embodied engagement model in interacting with ambient media

5.5.2.1 Encounter

The first stage of engagement is to inform audience perceptual clues that can potentially engage them in interactions. Sensory perception plays a major role in driving initial engagement with PS. In the beginning the participants encountered PS, most of them are attracted by the visual design, as the white color is distinctly different from the common grey color of stairs. A few of them are engaged by the musical sounds before they saw the staircase, when some other participants were playing there. Therefore, catching audience's attention through different sensory affordances (visual, auditory, tactile) is crucial for motivating their interest of participation in this stage. The visual perception indicates clue of possible bodily movements: the physical form of PS can potentially "invite" people to step on. In addition, sensory affordance also give rise to the visual mapping between the staircase and the piano image, as many participants consider it is an interesting design to resemble the shape of piano. Although PS primarily provides sensory affordances in this stage, this does not mean other kinds of affordances cannot engage audience. For different ambient media works, the intensity of each type of response varies in terms of the nature of the work. For example, the interactive bus stop (see 4.3.1) provides text information to inform audience how to interact with it. Beside the shape of a battery and color (sensory affordance), the text description serves as cognitive affordance which indicates audience could put hands on the plate to trigger the further interaction. The Social Swipe (4.3.5) also uses a large text sign "Feed them!" to elicit the passer's initial interest, which provides both sensory and cognitive affordances to engage audience in the first encounter.

5.5.2.2 Adaptation

Different from the phase of initial encounter, physical affordance and sensory affordance have dominant effects on adaptation of the interaction with PS. The major physical affordance of PS is eliciting participant's physical actions (e.g., step, stride, run, jump). Employing innate bodily structure and bodily

skills, participants perceive the physical shape and spatial features of the staircase and then perform different bodily actions.

In this early phase of engagement, most of participants have no specific intention about how to interact with PS. They spend a period of time getting familiar with work. A few participants mentioned, after stepping on PS in the beginning, they immediately tried to experience all stairs one by one to seek what would happen. The duration of adaptation varies for different participants, who have different backgrounds and skills. Many participants can understand the basic relation between bodily movement (input) and auditory feedback (output), and the relation between stair levels and musical sounds after they walk up or down one or two times. Many participants felt surprised to hear the musical sounds when they first stepped on the staircase. PS does not create high level of cognitive and emotion experiences, but the participants gain some initial understanding and emotional responses in this stage.

5.5.2.3 Anticipation

After getting some initial experience with PS, many participants express their expectations for further exploring the work. They expect to perceive a particular feedback by performing a certain action. For the behavioral features of this phase, they usually pause for a short term when standing or keep in a posture. Because the bodily skills and depth of adaptation vary from person to person, the participants have different anticipations which mainly focus on what feedback they could generate and what bodily actions they might perform. Some participants, who declared they had some piano performance skill, had an intention to play a music composition or a little tune through interacting with PS. P3 mentioned "I can play piano, so when I saw this piano staircase I really want to play a composition on it. I would like to play this for my friends." Apart from playing compositions, two participants

(P8, P9) intended to step on all the stairs one by one and to see the musical effects. P9 described “After I initially stepped on it, I suddenly heard the music, and I wanted to play all the keys and to see whether the notes sequentially match each stair.” Two participants (P9, P26) mentioned they expected the stairs can have some lighting effects when the musical sound was simultaneously triggered. P5 and P7 want to perceive the elasticity of stairs after leaving their feet from stairs like the piano keys bouncing up. Three participants (P10, P23, P27) mentioned they would like to play PS with other people rather than individually walk there. Overall, this engagement phase, to a large extent, belongs to cognitive processing in which the participant intends to make expected feedbacks based on their initial experience.

5.5.2.4 Exploration

The participants employ their physical bodies to explore the work or test their expectations through various bodily movements. Similar to the phase of adaptation, the physical affordance and sensory affordance of this phase are to trigger bodily interactions and perceptual responses. But, the engagement of this stage is more intended to achieve potential results, according to the anticipation in the last phrase. For example, after adapting to the musical sounds, P7 deliberately stepped on the black keys for seeking different feedbacks. Some participants changed their walking speed to generate new music feedbacks. Four participants explored different movement patterns by performing different actions. They strode, stamped, or ran on stairs to trigger musical effects. P19 said: “I tried to generate longer musical sound by staying on one stair for a while.”

Apart from visual and auditory perception, the most significant feature of bodily movement-based engagement is that it can give rise to kinesthetic sensations which are related to the direct perception from internal body parts and muscles during moving process. As shown in results, many participants

described their body's feelings about force and energy (e.g., tiredness, heaviness, lightness, fluency) in terms of their moving speeds, forces, and directions, which elicit their emotional responses (e.g., happiness, relaxation, fun) and corresponding metaphorical meanings.

5.5.2.5 Evaluation

The phase of evaluation is to appraise the whole interaction and give rise to embodied metaphorical meaning and emotional experience. After exploring PS through bodily interactions, participants immediately appraise that whether the interactive experience is in line with the prior anticipation or not. The major affordance of this phase is to motivate a participant to evaluate and reflect his or her overall experience including sensory, physical, and emotional responses. The cognitive activities also include imagination and recall. Some participants mentioned that the distance between two stairs were too far, and they cannot reach it through stretching legs to generate a tune or chord. A few participants felt the feedback of stepping was too hard, as they can feel a force of rebound after pressing keys on real piano. Many participants emphasized that it was a novel and different experience to walk on PS, and the overall feeling was active. Some other participants also considered this music staircase is dynamic and interesting, previously walking on stairs was very boring, walking on this staircase is relaxing, and it can change people's behaviors and attitudes toward positive direction.

Based on the experience evaluation, there are two possibilities: Re-engagement or exiting from engagement. Some people may have new anticipations and continue to explore the work, while others choose to end the engagement. This engagement model is built based on the data analysis of the case PS. It illustrates a basic process of embodied interactions with ambient media in terms of temporal and experiential components. However, the intensity of each type of affordance or experience may vary for a different

person or work, because the individual experiences in the past (e.g., bodily skills, cultural skills) also have large effects on the immediate interaction, and a different ambient media work also provides a various intensity for each type of affordance or experience in each engagement stage.

5.5.3 A unified model of audience experiences

The two models provide useful guidance for understanding audience experiences in terms of meaning making and engagement. However, whether the two models are applicable for analyzing other ambient media works? Following an iterative research process, this section attempts to use the embodied engagement model to reanalyze two ambient media works in Chapter 4: *Social Swipe* (4.3.5) and *Moment of Warmth* (4.3.1), which is aimed to evaluate and consolidate these models.

5.5.3.1 Reanalyzing Social Swipe

Audience experiences with Social Swipe are interpreted in terms of the engagement process.

Encounter: When people pass by the installation, they may notice the sign “Feed them” which elicits initial cognitive response (motivating donation).

Adaptation: The audience may get closer and view the short animation, and meanwhile the arrow lighting up hints at the direction for swiping the credit card (High intensity: sensory response).

Anticipation: The audience may have expectations (swiping leads to a certain outcome) on the installation (High intensity: cognitive response).

Exploration: The action of swiping card activates the animations of cutting off a piece of bread or a rope tying hands (High intensity: bodily response and sensory response).

Evaluation: The interactions between the audience and the installation inform that a small action makes positive effects on poverty (High intensity: cognitive

and emotional response). The audience may continue to anticipate the engagement and donate it again.

These interpretive analyses show that the engagement model can potentially evaluate the process and quality of experiencing an ambient media work.

Regarding the embodied meaning making model, the metaphorical expressions are mainly generated in Exploration and Evaluation. During exploring, swiping card (immediate bodily movement) activates the mapping between Removal (embodied schema) and freeing the hands from constraint (the source domain of embodied metaphor), which expresses “Helping those in poverty and hunger” (metaphorical expression or target domain of embodied metaphor).

5.5.3.2 Reanalyzing Moments of Warmth

Encounter: When passersby approach the bus shelter, they may notice the vivid red color, hand symbols on the two sides, and the battery-like shape on the roof, which mainly gives rise to sensory responses (High intensity: sensory response).

Exploration (Adaptation): People hold their hands together and touch the area of hand symbol, which triggers that heater on the top of the shelter (High intensity: bodily response and sensory response).

Evaluation (Understanding): Connecting hands between people gives rise to an expression of solidarity and synergy, and physical warmth can elicit psychological warmth. The enclosed shelter also unconsciously implies a secure and intimate feelings (High intensity: cognitive and emotional response).

Embodied meaning making model, the metaphorical expressions are mainly generated in Exploration and Evaluation. Firstly, people’s actions (immediate bodily movement) activates the mapping between Part-Whole (embodied

schema) and holding each other's hands (source domain of embodied metaphor), which expresses "Connecting together generates solidarity and synergy" (metaphorical expression or target domain of embodied metaphor). Second, the emerging red color and physical warmth of the heater metaphorically express warm feeling in emotion and cognition.

As it is hard to allocate the experience process of Moment of Warmth in five stages, the process is synthesized as three engagement stages (Encounter, Exploration, Evaluation) that embody how audiences engage in the whole experience process as well as four interrelated experiential modules.

5.5.3.3 Developing a unified model

Comparing the two case analyses, the engagement stages for Moment of Warmth are less than these for Social Swipe, which means that the embodied engagement model (five stages) cannot be universally applied in analysis of all ambient media. The intensity of each type of affordance or experience may vary for a different person or work, because the individual experiences in the past (e.g., bodily skills, cultural skills) also have large effects on the immediate interaction. Different ambient media works have various patterns in intensity for each type of affordance or experience in each engagement stage.

Based on these considerations, it is necessary to build a unified model that can be applied for analyzing all ambient media works and informing design practice. There two aspects in the five stages model (Figure 5.16) needing to be reconsidered: 1) How can the engagement process (stages) be more applicable for all ambient media? 2) How can the model of embodied meaning making (Figure 5.18) be integrated with the engagement process in one unified model?

In order to achieve these goals, this study firstly compares and reanalyzes the engagement stages in case analyses and the previous models, the five stages of engagement are synthesized into three “E” phases: Encounter, Exploration, Evaluation (Understanding) (Figure 5.17).

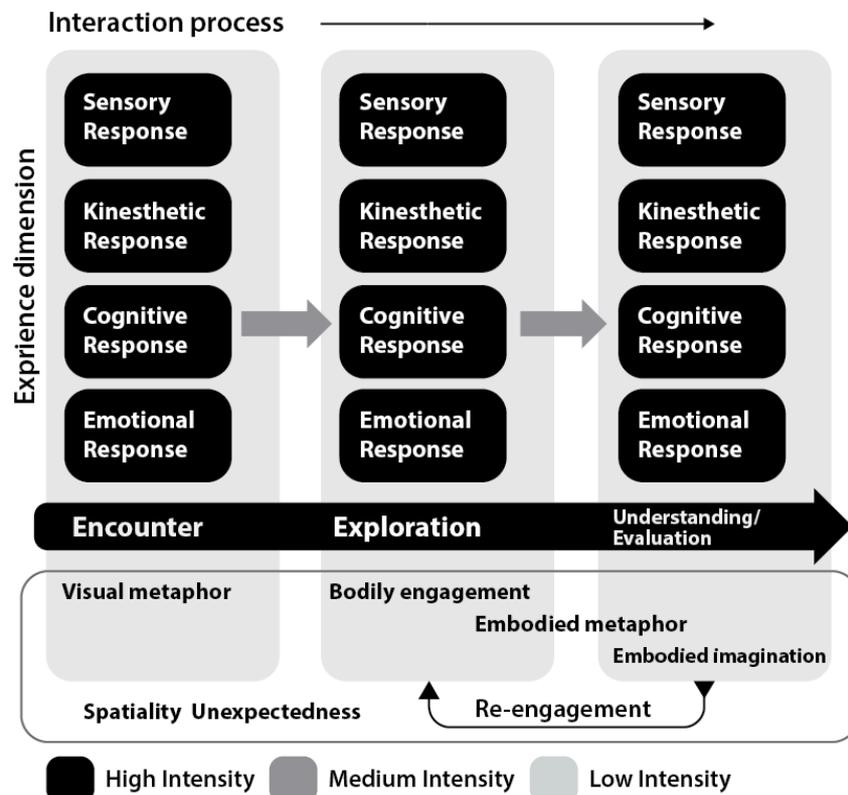


Figure 5.17 Unified model of engagement and meaning making

There are two major reasons for this synthesis: According to the case analyses on Piano Staircase, Social Swipe, Moment of Warmth, some engagement stages have similar patterns on intensity of experience modules. For example, when audiences experience these works, sensory response and physical response usually embody high intensity in both stages of Adaptation and Exploration, and Anticipation and Evaluation exhibit high intensity in cognitive and emotional responses. Moreover, Exploration can be regarded as a higher level of Adaptation or reengagement from adapting the work. Evaluation share similar cognitive process with Anticipation, and they both are appraisals of bodily interaction with the work. It is an iterative process from Adaptation

– Anticipation to Exploration – Evaluation. Therefore, the synthesized process comprises three essential engagement stages that reflects the audience’s embodied experience in a temporal dimension.

The process of embodied meaning making needs to be considered in the context of three properties of ambient media: engagement, unexpectedness, and spatiality (small black frame). For engagement, embodied metaphorical mapping is combined with engagement stages. The two properties unexpectedness and spatiality are not elements for a specific engagement stage, and an audience may have expected feelings at any possible moments. For example, a few participants mentioned they felt surprised or unconventional when seeing the piano-like staircase in Encounter, while some participants also mention they got unexpected musical feedbacks by bodily interacting with the staircase. Spatiality means that audiences are engaged in and experience ambient media in public spaces. These properties integrated with engagement process and experience modules construct a unique embodied interaction model for experience with ambient media. All four experience modules are filled with black in this model, but if it is applied to analyze a specific work, the intensity of each experience module in every stage may vary.

This unified model integrates experience dimension (four types of response), engagement process, and properties of ambient media, which provides a holistic and systematic perspective for research in ambient media design.

5.6 Summary

This experimental study empirically investigates the mechanisms of embodied interaction and engagement with the interactive prototype Piano Staircase, and the main characteristics of embodied experience also were identified

through experience tests and thematic analysis. The study indicates that the interaction with ambient media is a process of embodied engagement which allows audience to make embodied meaning in terms of both past and real-time bodily experiences. The findings of this study are twofold. First, meaning making in interacting with ambient media is structured by pervasive embodied schemas originating from past bodily experience, and tied to immediate bodily states. The model of embodied meaning shows that bodily action is not only an input element for triggering interaction but also a major source of embodied metaphorical mappings and facilitating meaningful audience experiences. Second, the embodied engagement model integrates psychological dimension of experience with bodily movement-based engagement process, which provide systematic guidance for designers and researchers to understand audience experiences and design meaningful interaction with ambient media. This empirical study substantiates the previous embodied metaphor-related research and makes new contributions by presenting three models for understanding embodied engagement and meaning making in interacting with ambient media.

Chapter 6. Designing Ambient Media³

6.1 Introduction

6.2 Pilot study

6.2.1 Design workshop

6.2.2 Prototype A

6.2.3 Prototype B

6.3 The relationship between embodied schemas and spatial features

6.3.1 Containment

6.3.2 Path

6.3.3 Orientation

6.3.4 Other embodied schemas

6.4 Designing embodied interactions with ambient media

6.4.1 Developing new design ideas

6.4.2 Analysis of design ideas

6.4.3 Experience prototyping and design evaluation

6.4.4 Discussion

6.5 Summary

6.1 Introduction

The preceding chapter presented an in-depth experimental study on audience experiences with ambient media, which focuses on investigating the role of bodily movement in metaphorical meaning making. Based on the findings from the case study and empirical study, this chapter aims to explore how these models and strategies can inform the design of ambient media, and further develop an embodied approach by developing original designs that

³ Parts of the author's own papers "Tan, L., & Chow, K.K.N. (2018). An Embodied Approach to Designing Meaningful Experiences with Ambient Media. *Multimodal Technologies and Interaction*, 2(2), 13" and "Tan, L. and Chow, K.K.N. (2018). *Coupling Environmental Affordances with Schematic Meaning: A Matrix for Designing Embodied Interaction in Public Spaces*. In Proceedings of the Sixth International Symposium of Chinese CHI ACM, Montreal, Canada" are included in Chapter 6. Longer sentences, phrases, and paragraphs are referenced.

facilitate engaging and meaningful experiences. Through ideating, sketching, prototyping, experimenting, and analyzing, this study is able to evaluate, validate, and reframe previous models, and propose a feasible embodied design approach to designing ambient media. The researcher, as a reflective practitioner, engages in design activities to experience and understand the process of designing. This chapter first conducts a design workshop as a pilot study to initially explore how generic design strategies derived from previous studies can be applied into ambient media design. Then, based on the pilot study, a matrix reflecting the relationship between embodied schemas and spatial features is developed. Next, the researcher conducts design ideation by applying the strategies and the matrix, and ten design ideas are analyzed based on in terms of four criteria. Furthermore, experience tests on the prototype of Reading Door provided empirical evidence to support the analysis on design ideas. The pilot study and design experiments indicate that the embodied approach is applicable for designing embodied interactions with ambient media. Three design principles are also proposed for ambient media design.

6.2 Pilot study

Previous chapters conducted theoretical research, case analyses, and empirical study, which established a solid basis for the analysis and design of ambient media. Now the major challenge remaining is how these embodied models (Figure 4.11, 5.15, 5.17) could inform designing for ambient media and guide designers in the development of ambient media design. This section conducts a design workshop to explore how generic design strategies derived from previous studies can be applied into ambient media design.

6.2.1 Design workshop

A design workshop was conducted by inviting two groups of students of Interactive Media Design (School of Design, The Hong Kong Polytechnic University) to design two ambient media prototypes, which aimed to see whether the insights from interpretive and empirical studies can help designers to develop ambient media works. In the subject of Interactive Media “Studio II - Networks & Communities”, the researcher as a tutor guided two groups of students (four students in each group). The topics generally covered a range of global issues (e.g., hunger, environmental protection, sustainable cities, ocean pollution), and the students were required to develop an interactive installation allowing people to experience, understand, and empathize a condition (problem). In the tutorials, basic concepts and findings from two studies were introduced. Then, four design strategies derived from previous two studies were provided to the students:

- 1) Incorporating the installation into the everyday public environment.
- 2) Eliciting unexpected experience by designing input - output relations.
- 3) Coupling audience’s bodily actions with sensory feedback in regard to embodied meaning making.
- 4) Considering the congruency between spatial structure (embodied schema) and everyday bodily actions.

Once the two groups have chosen their specific topics, they were advised to develop design ideas by considering these strategies. As in this pilot study some concepts (e.g., embodied schema) are difficult for students to understand, the researcher just provided relatively general guidance on the embodied models which were intended to test how the participating students can employ them to contribute to their designs of ambient media. The following section will briefly review the design process of two groups in regard to these design strategies.

6.2.2 Prototype A

Group A (Cheng On Ting, Chan Sui Fung, Tsang Tsz Yan, and Chiu Chong Wa) chose the topic marine pollution related to the global issue “Life below water”. As in the early stage, the designers were asked to discuss some relevant key words related to their topics, and then they could associate these words with everyday environments and bodily experience. In the first week, they brainstormed waste disposal behaviors in regard to the marine pollution, and lots of different initial ideas were. Then, there was a round comparison and discussion to screen one scenario that was most congruent with the topic and in line with the four strategies. Inspired by the motion of water and the behavior of picking up rubbish, Group A proposed airport conveyor belt as a basis for designing ambient media, and Figure 6.1 shows the sketch of ideation, as there were two embodied metaphorical mappings: 1) The moving conveyor belt can be designed to resemble ocean water flow (visual mapping and Path schema), which construct a physical context. 2) Picking up their luggage from the conveyor belt can be a way to metaphorically express the meaning of cleaning up the rubbish in ocean (Removal schema). Another idea of interaction design was that the waste disposal percentage (displayed on the screen) would be decreased when people used smart phone to scan QR code on the rubbish. To compare the two ideas about bodily interactions, the author guided Group A to conduct participatory design workshops. Nine participants were invited to experience the prototype (Figure 6.2) and give feedbacks. Many participants mentioned that they prefer diminishing the images of garbage by hand gestures. They felt that taking luggage from the belt was related to cleaning garbage (images of garbage were projected on luggage cases). The behavior of scanning QR code was not very active and not related to “removal” (Schema) of pollution.

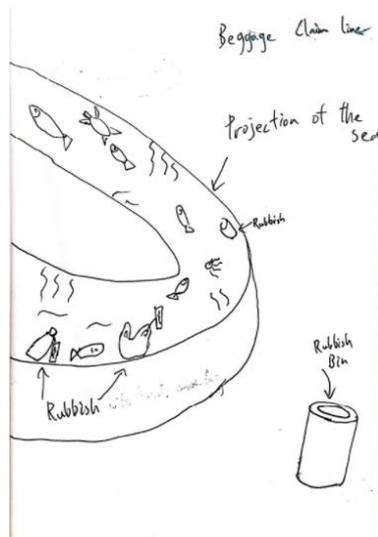


Figure 6.1 Sketch of Group A



Figure 6.2 Experience prototype of Group A

6.2.3 Prototype B

Group B (Lee Hoi Lam, Lam Hiu Tung, Chung King Tin, and Chau King Wing) centered on the topic of paper waste related to “Sustainable communities”. The group members viewed relevant videos and information such as paper consumption as a main driver of forest degradation, and then they linked people’s everyday behaviors of using paper towel (Figure 6.3) to the wood industry contributing to deforestation. Inspired by the design strategy of the embodied metaphorical mappings between bodily actions, they developed a

design idea (Figure 6.4) that the bodily action of tearing towel paper can metaphorically express destroying forest.



Figure 6.3 Pulling towel paper

The design prototype was proposed to set up in the washing area of public toilet. The interaction between audiences and it was aimed to give rise to two metaphorical mappings: 1) When an audience tears (Splitting schema) a paper towel from the dispenser, the video on the mirror (screen) displays that a tree is being cut down by sawing and a forest is disappearing. 2) Reminded by the video, the audience shake hands in front of the washbasin to remove water, and meanwhile a video showing trees are growing (Scale schema), which metaphorically expresses behavioral changes can contribute to sustainable communities.

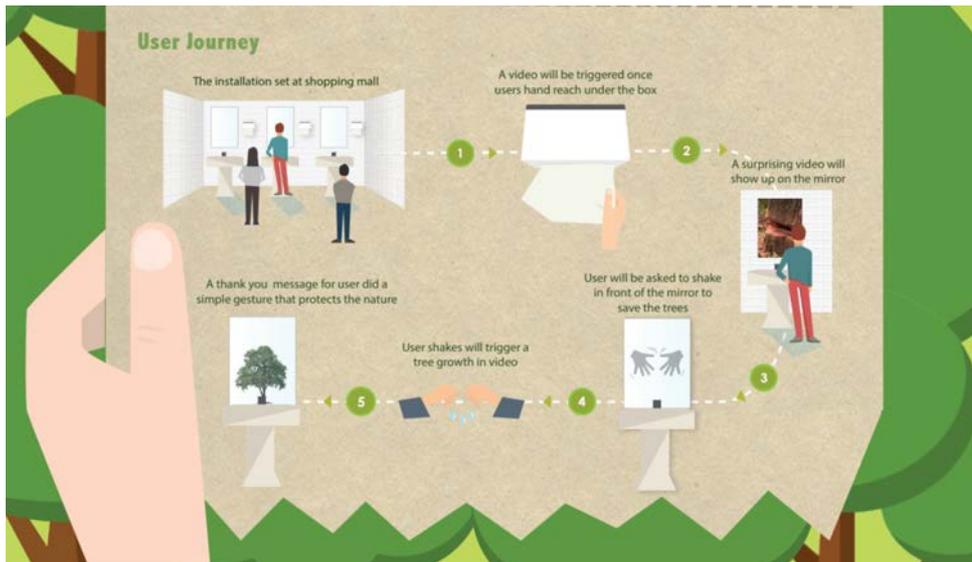


Figure 6.4 Sketch of Group B

The preceding section explores how the embodied interaction models can help designers to develop ambient media prototypes through two pilot studies. The results indicate that the four strategies (6.2.1) are applicable for guiding idea development of ambient media design in regard to embodied meaning expression. The pilot study also shows that designers usually start to ideate design concepts from a public location or everyday bodily movements. Accordingly, a direct question is how embodied schemas can be linked to various features of public spaces in regard to people’s behaviors.

6.3 The relationship between embodied schemas and spatial features

As discussed in literature review, embodied schemas arise from long-term bodily experience with environments, and the spatiality of a public space provides certain affordances for bodily interactions (see Figure 4.11). This indicates that coupling bodily actions with embodied meaning can be a starting point in designing embodied interactions with ambient media.

How can embodied schemas be linked to public space in regard to bodily interactions? Johnson (1987) uses “schema” to refer to the experiential structure emerging from perceptual and motor interactions with various physical environments. Based a range of embodied schematic structures discussed in previous studies (Evans & Green, 2006; Johnson, 1987), this section formulates a matrix to explore the relationship between various spatial features in public space and embodied schemas (Table 6.1). The matrix indicates that the features of public spaces and everyday objects provide corresponding action possibilities, which are linked to a range of recurrent mental patterns. For example, a corridor is related to Source-Path-Goal schema and offers affordances of walking through it, and a staircase is about Orientation schema and provides affordances of walking up and down, forward and backward. Relevant cases are also listed in the table for reference.

	Container	Path (Locomotion)	Orientation (Up-Down, Left-Right, Near-Far)	Force (Blockage, Gravitation)	Existence (Removal, Object)	Unity (Combination, Link, Splitting)
Bus stop	Moments of Warmth					
Elevator	Shark Week Campaign		Thermometer Elevator			
Corridor		The River (Quai Branly)				
Staircase	Mini (car)		Piano Staircase	Piano Staircase		
Floor				The footprint poster		
Wall			Nike-Building Twist		Smooth Valentine’s Day	
Door		Revolving Doors	Europe. It's Just Next Door			

Ashtray				Smoking Causes Blindness		
Luggage belt		Marine Pollution				
Button				Bubble Wrap (PS2)		Plastic Surgeon elevator
Credit card						The Social Swipe

Table 6.1 Matrix of embodied schemas and spatial features

6.3.1 Containment

First, Containment is related to a pervasive characteristic in people’s everyday life: experiencing In-Out spatial relations to physical space or object, which also implies a sense of spatial boundary. Containment is formed in people’s early life experience across cultures. For example, people need to constantly walk in or out of physical spaces (e.g., room, building), and put objects (e.g., fruits, water) in or out of different containers (e.g., basket, cup). People wrap clothes around their bodies and the body sometimes is out of clothes. Room, building, basket, cup, cloth are various spatial containers (bounded space) which separate things into different spaces. People’ everyday life experiences these spatial understandings and hence constructs the embodied mental pattern Containment. The table includes two cases about Containment: “Moments of Warmth” (Figure 6.5) and “Shark Week Campaign” (Figure 6.6). As analyzed in Chapter 4 (4.3.1), people walk into the bus stop and then experience a semi-enclosed space (Containment) which gives rise to a feeling of solidarity and warmth. Shark Week is a shark-related TV program and made a campaign by designing with the elevator (Brad, 2013). The interior of the elevator was designed like a cage with iron railings surrounded by a picture of underwater ocean scene. When people who walk inside the elevator may have a sense of being in deep ocean and can see sharks swimming outside of the cage. Although people may feel dangerous when seeing sharks, the cage

provides a metaphorical meaning of protection which is rooted in Containment schema. This sense of protection is very in line with the description of Johnson (1987, p. 23): “The experience of containment typically involves protection from, or resistance to, external forces.”



Figure 6.5 The bus shelter of Moments of Warmth



Figure 6.6 Shark Week

6.3.2 Path

Path schema is a pervasive schematic structure comprising the start and end points which are connected by a sequence of moving locations. From-To and Source-Path-Goal are two forms of Path schema. People constantly experience a process of moving from a place to another: Walking from living room to bathroom, throwing a basketball to the basket, looking from here to

there, riding bicycle to school, a plane flying from a city to another, a road connecting two buildings. These difference paths constitute people's everyday experience and comprehension. The example "The River" (Figure 6.7) is an ambient media work in Quai Branly museum of Paris (Sandison, 2010). The corridor with a curve shape connects the lobby and the exhibition floor. The designer employed the corridor as an interactive interface by projecting motion texts along the corridor and simulating the effect of flowing river. Visitors' behavior of walking along the corridor typically embodies schematic structure Path, as the walking experience is accord with the features of Path schema: the beginning, the end, and the connection of a series of contiguous locations. The dynamic text flow augments the schematic feature of the corridor, and people were attracted to behave in different bodily states (e.g., looking down and contemplating the text flow, walking by following the text flow's shape). These interactions with the corridor mixed with digital motion image metaphorically express a sense of history, culture, time, and nature, and walking on the corridor is not only a behavior of using physical facility but also an experience of a time line mapped onto the path.



Figure 6.7 The River

Revolving Door (4.3.10) is a case embodying circle Path, as people push the door to make it and the dancer rotate along a circle path. This combines two movements with similar property, which brings interesting and impressive experience and directly deliver a message about a ballet school.

6.3.3 Orientation

In categorization of Evans and Green (2006), they defined eight categories of image schemas, where Space schemas include Up-down, Front-Back, Left-Right, and Near-Far, Verticality and the others. This research considers the term “Space” is a little general for this category, and Orientation is a more appropriate term for these orientational schemas. People experience different spaces and make meaning about orientation in terms of the body as reference. People walk forward or backward on road, go upstairs or downstairs, turn left or right, see something near or far, stand vertically and lie horizontally. These everyday bodily experiences contribute to stable and fundamental structure about orientations and spatial relations. Spatial features afford various action possibilities: the ground affords walking forward or backward, and a staircase affords actions for going up or down. In some sense, the affordance is the physical basis in environments that shape embodied schematic patterns and the way people behave in situated interaction. These schemas related to orientation extensively exist in people’s everyday lives. In chapter five, I have investigated a range of conceptual metaphors that are structured by orientational schemas through an empirical study. Perceiving the change in spatial levels of Piano Staircase and musical notes gives rise to metaphorical concepts related to orientation (high and low in pitch). In the case “Nike – Building Twist”, the wall of outside the factory has a vertical orientation from the ground to the sky. Opposite to this verticality, the projection on the wall shakes when the audience twists the shoe. “Europe. It's Just Next Door” also embodies Orientation schema, as

audiences experience a relationship between the remote space (Front) and the current space (Back) after they open the door.

6.3.4 Other embodied schemas

As shown in table 6.1, the other three categories of schemas include Force, Existence, and Unity. Chapter 5 (5.5.1) have discussed that Force-related schemas play an important role in meaning making in interacting with Piano Staircase. Based on the findings from this empirical study, I categorize four works into Force schemas: *Piano Staircase*, *The Footprint Poster* (Figure 6.8), *Smoking Causes Blindness* (4.3.8), and *Bubble Wrap* (4.3.6). Force schemas are formed in long term forceful interactions (e.g., Gravitation, Removal of Restraint, Blockage) with various objects and environments. The qualitative analysis (5.5.1) indicated that embodied experience with *Piano Staircase* involved Gravitation and Removal of Restraint schemas, as the participants perceived both internal forceful responses (kinesthetic sense) and external forceful responses (tactile sense) which give rise to various metaphorical imaginations (e.g., waterfall) and concepts (e.g., relaxation). *The Footprint Poster* is an ambient media work about wild animal protection (WWF, 2014). The railings gradually appear when passersby walk over the poster on the ground, and then the panda bear looks like being locked in a cage. People's bodily engagement with this work metaphorically delivers a message that the intervention of human activities can have a negative effect on wild animals' lives. The interaction's feedback (the emerging railings) results from the Counterforce relationship between passersby's forceful actions and forceful resistance of the ground. *Smoking Causes Blindness* is also related to Counterforce, as pinching off the burning cigarette on the eye-shape trash bin is like attacking or destroying something, which metaphorically means smoking is harmful to eyes. *Bubble Wrap* is about Removal of Restraint schema, Passersby could use their fingers to press these bubbles like playing the Sony's video games by striking the controller's buttons, and this

unconventional approach made a very engaging and unique way to exhibit products to potential consumers, who might spend their waiting time popping the plastic bubbles with a playable and joyful experience.



Figure 6.8 The Footprint Poster

In the case *Smooth Valentine's Day* (4.3.4), With more and more passers taking roses, the stems (whiskers) were gradually moved away, and a clean face appeared. This metaphorical meaning is an extension of Existence (Removal) schema. *Plastic Surgeon Elevator* (Figure 6.9) (Semih, 2011) and *The Social Swipe* belong to Unity schemas. When the passerby presses the button on the panel outside of the elevator, it forms a unity with the God and metaphorically means this clinic can bring the patient a new life. As the case analysis (4.3.5) has described, the actions of cutting the rope and the bread metaphorically denote eliminating poverty and hunger through donation. This embodied metaphor is structured by Splitting, a scheme in category Unity.



Figure 6.9 Plastic Surgeon Elevator

This section creates a table to exhibit that a range of public spaces and objects have physical affordances in eliciting embodied meaningful interactions between audience and ambient media, and the metaphorical meanings are extended from the recurrent mental structures that arise from long term repeated sensorimotor experience. The matrix of embodied schemas and spatial features provides a practical guide for designing ambient media in regard to employing elements in public space as the interface for meaningful interactions.

6.4 Designing embodied interactions with ambient media

Grounded in embodied interaction and cognitive semantics, the preceding chapters have theoretically and empirically investigated audience experiences with ambient media. These analytical studies indicate that the nature of audience experiences with ambient media is inherently embodied, and bodily engagement, as the major source of meaning construction, activates image schematic metaphorical mapping from concrete representation (e.g., fast movement on Piano Staircase) to abstract concept (e.g., fluency). Based on promising results from both interpretive case study and empirical experiment,

the model of embodied meaning making (Figure 5.15) and embodied engagement model (5.17) for understanding audience experiences are proposed. The pilot study on designing ambient media indicated that the strategies (6.3.1) derived from the two models (findings) can help designers ideate in the process of ambient media design. This suggests that embodied schemas can be linked to various features of public spaces in regard to people's behaviors. Correspondingly, a matrix (Table 6.1) was built to articulate the relationship between various spatial features in public space and image schemas. Regarding these findings, the main question this chapter is concerned with how to further evaluate the embodied approach.

In order to further understand designing meaningful interaction with ambient media, and this section will continue to explore how the previous findings (e.g., the model of embodied meaning making, design strategies), as an embodied design approach, can guide designing meaningful experience with ambient media in consideration with image schematic meaning structures, and what design principles can be revealed to support design practice. In line with the idea of Research through Design (Jonas, 2015), this study is guided by a designerly process aiming at design approach evaluation and knowledge generation through the active participation of the researcher (also as a designer) in designing and inquiring. This is expected to open up new discussion on ambient media design and embodied design thinking. The study on designing ambient media is composed of four phases: 1) Developing new design ideas. 2) Analyzing design ideas. 3) Experience prototyping and experience tests. 4) Reflection on ideation process.

6.4.1 Developing new design ideas

Before ideating design ideas, this study firstly prepared some topics as the thematic direction for development. Inspired by the topics in BAIM (Bachelor of Interactive Media in School of Design at the Hong Kong Polytechnic

University) subject “Studio II - Networks & Communities”, the ideation started with *the Global Goals* for sustainable development proposed by the United Nations (UN, 2015), which target to enhance life quality (e.g., good health, quality education) and reduce environmental pollution. Then, the researcher developed ten design ideas by applying the embodied design approach, and ideation process is described as follows:

1) Basket Trash Bin

Throwing trash carelessly in public spaces is a common phenomenon in many developing countries. In order to encourage people to drop litter in trash bin rather than the ground, the researcher tried to ideate with the schematic structure of trash bin and people’s everyday actions. Trash bin is a container that people constantly put something into or take something from. The bodily actions of dropping litter into the trash bin and throwing a basketball into the net have similar schematic pattern. They are all about exerting a force to bring an object into a container. The difference is that playing basketball is more interesting than throwing trash. In regard to the same embodied schema, the researcher designed a basket trash bin by incorporating the backboard of basketball game and a trash bin (Figure 6.10). When a passerby throws trash into the bin, the behavior is like throwing a basket ball into a net, and the hidden speaker plays a sound of cheer. The main design inspiration is bodily interaction with the schematic structure Container, and it constructs the metaphorical mapping between the action of throwing a basketball and the action of dropping trash, as a way to motivate people to drop trash properly and accurately.



Figure 6.10 Basket Trash Bin

2) Reading Door

The topic is about encouraging book reading through meaningful interaction, and it is related to the global goal “Quality Education”. The design idea was generated from the everyday action of opening a book. There is a similar embodied schematic structure between opening a door and opening a book, since people constantly experience entering and opening bounded spaces (room, box), which gives rise to an embodied schema Container. The design transforms the door of a building entrance into interactive ambient medium (Figure 6.11). The surface of the door is decorated like a book cover. When a passerby pulls the handle, the separated layer is flipped over, but the door is not actually opened, and a quote appears on the white door: “A book is a gift you can open again and again –Garrison Keillor”, and in the meanwhile, a sound of flipping book pages is played. The embodied metaphor is activated through the action of opening the “door” denoting a meaning of reading book. This embodies the three attributes of ambient media.



Figure 6.11 Reading Door

3) Social Bench

This design is concerned with a problem about social isolation caused by excessive use of smartphone or fast pace of modern life. The ideation of this idea starts with the concept “connecting people” in public space, and how to facilitate people’s communication in a meaningful way. The bench in public park was chosen as a medium for social interaction (Figure 6.12).



Figure 6.12 Social Bench

When someone sit on the bench alone, a light effect will appear around the person, which may attract other passersby's attention. Then, if another one sits on it, their positions are connected by a glowing line, which may motivate them to communicate with each other. This schematic metaphor is triggered by a sensorimotor interaction and structured by the embodied schema Unity (Link).

4) Hug Pole

This design is addressing a mental health issue that many people feel loneliness and coldness in winter (Figure 6.13).

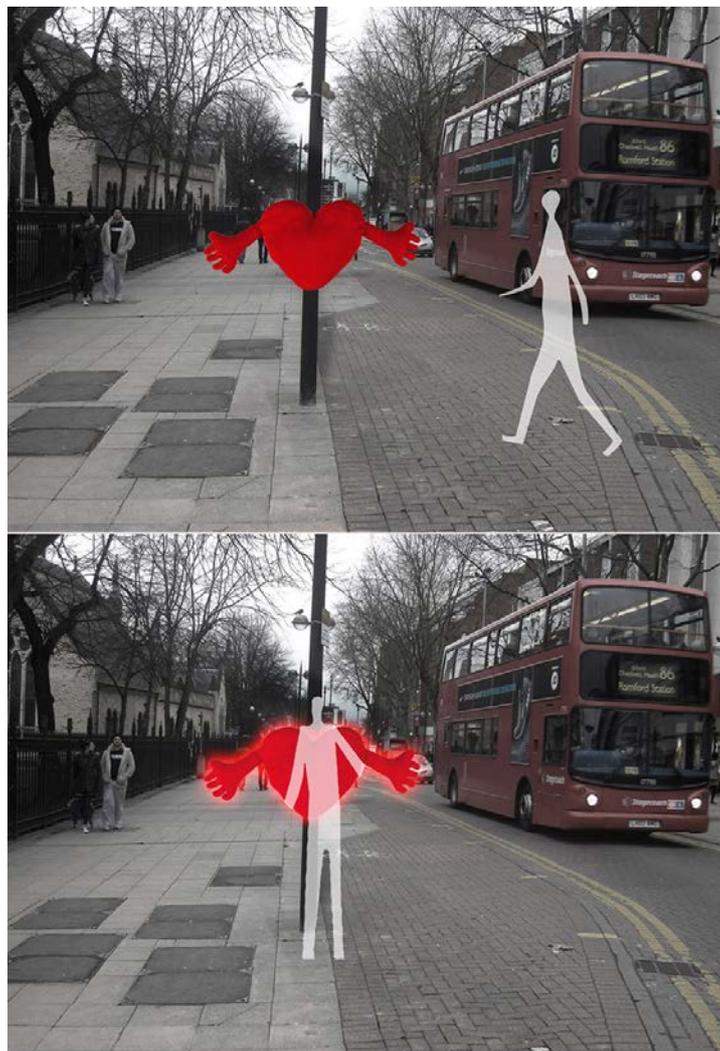


Figure 6.13 Hug Pole

The idea was ideated from an opposite direction of coldness and aimed to afford people warmth and closeness experience. Based on the orientation schematic structure Near-Far, the design was to provide a way in which people can engage in bodily interaction with sensory and physical warmth, and then this can give rise to a psychological warmth and closeness. A heart shape cushion is installed on a street pole, which afford possible actions of hug or touch. If a passerby hugs the cushion tightly, he/she will gradually perceive warmth from the cushion that will simultaneously glow with red light. The embodied metaphorical mapping from physical warmth to psychological warmth and closeness is activated through bodily actions (i.e., approaching the pole and hugging the cushion), and the sensory feedbacks of physical warmth and light effect further amplify the embodied schematic metaphor.

5) Book Staircase

This design's topic is similar to "Reading Door" about promoting book reading. The staircase of public library is chosen as the medium for interaction. The form of stairs resembles the book (Figure 6.14), and the arrangement is like a staircase composed of books.

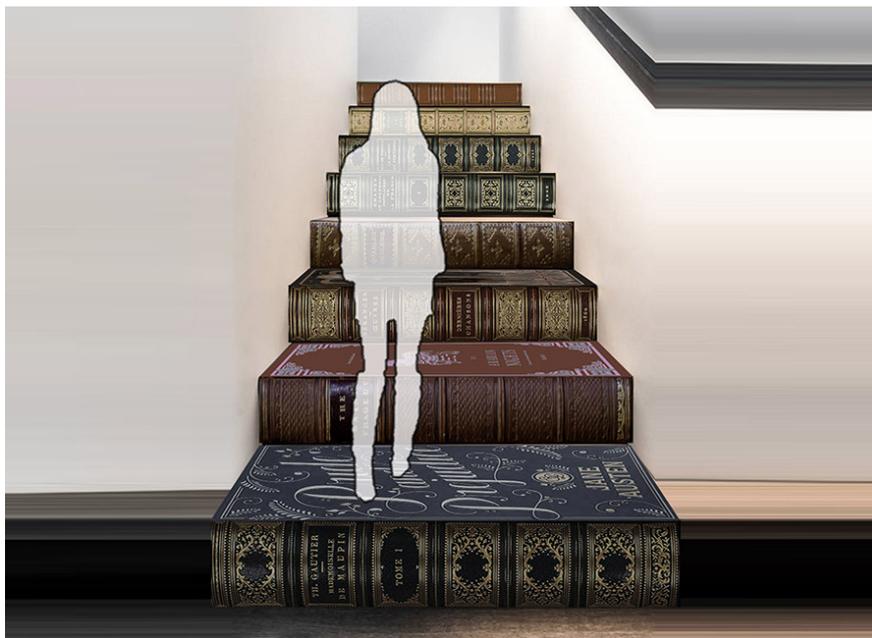


Figure 6.14 Book Staircase

When people walk on a stair, it triggers a voice reading a famous quote from a book. The bodily engagement with the work is related to two metaphorical levels: the first is visual metaphor resembling the shapes of two different objects (stair and book). The second is embodied conceptual metaphor extended from Orientation schema, which metaphorically means that book is “stair” that can bring people to a higher place.

6) Lighting Corridor

This design idea is advocating a message about positive attitude in university life. According to the conceptual metaphor “Life is a journey”, the temporal concept (life) can be understood in terms of the spatial concept (journey). In regard to the matrix of schemas and spatial features (Table 6.1), the researcher drew upon corridor as a medium to design embodied interactions, as the corridor potentially affords movement along a path. The corridor in the outdoor space of a university is chosen as medium for interaction (Figure 6.15). When the passerby walks along the corridor, the two poles ahead of him light up, which metaphorically express that the future life (of students and staff) is lit up and people should look into the future with hope. The two schematic structures Path and Orientation are related to this embodied interaction.



Figure 6.15 Lighting Corridor

7) Water Body

Water Body is concerned with one of UN Global Goals “Good Health and Well-Being”. Many people forget to drink enough water in daily lives. In order to raise awareness of keeping enough water in the body, the ideation started from the schematic structure Container, as human body can be regarded as a container according to image schema theory. The design (Figure 6.16) projects real-time body figure of the audience on the wall, and at first the water level indicates that the body comprises about 70% water. With time passing by, the water level will gradually decline, and in the meantime, a cup of water appears on the side. If the audience touches the cup by hand, the water level rises as

water is being added to the body. The metaphorical meaning mainly pertains to Container and Orientation (Up-Down) schemas.

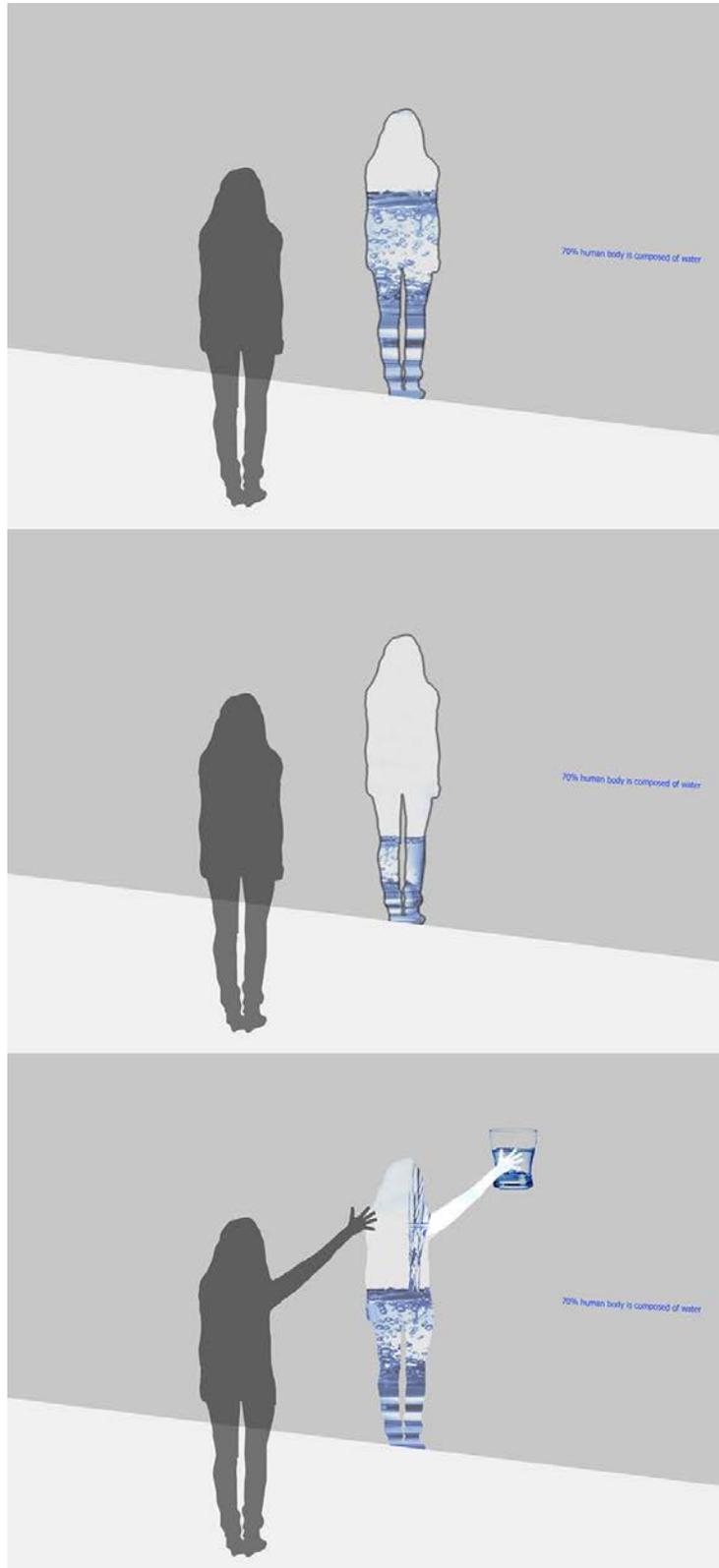


Figure 6.16 Water Body

8) Smile Mirror

Smile Mirror (Figure 6.17) pays attention to mental health problems (e.g., depression). Keeping smiling often is an important indicator of happiness and a way to maintain happiness. This design provides a medium by which people could experience their emotional changes. When a person goes to the public restroom (Figure 6.18), the mirror above the wash basin will reflect her face. If the facial expression is smileless, a mask will hide the face. Conversely, when smiling, the mask disappears and the smiling face is shown. This facial interaction metaphorically expresses that people should change toward a positive mental state, which is structured by Existence (Removal) schema.



Figure 6.17 Smile Mirror

9) Forest Floor

The design is to address the environmental problem of forest degradation caused by human activities. As shown in Figure 6.18, the floor of an indoor public space is used as an interactive interface of ambient medium. A forest scene with a bird's-eye view is projected on the floor, where the forest looks like from sky. When the audience pass the forest, the area around him becomes grey and looks like destroyed, and it will recover after the audience leave. which metaphorically expresses that human activities may lead to forest degradation. The image schema Removal, as a source domain in this embodied metaphor, is mapped onto the target domain “destroying forest”.



Figure 6.18 Forest Floor

10) Floating Belt

This design topic is concerned with increasingly severe marine pollution. In order to advocate awareness and action of protecting marine environment, the ideation started from the schematic pattern Path, and the luggage belt in airport was used as ambient medium interface, as its motion is like ocean flow. In addition, passengers in airport have to experience a period of luggage waiting time. According to a report, travelers in UK airports spent from 16 to 33 minutes waiting for luggage (Porter, 2014). The design takes the waiting time as an opportunity to create embodied engagement with the ambient medium (Figure 6.19). Before luggage arrives, ocean waves are projected on

the belt containing floating garbage. Passengers can clean garbage by waving hands, and once the hand shadow hides garbage, it disappears. When luggage arrives, the belt becomes clean ocean with fishes. The whole interaction is structured by Path schema and Removal Schema.



Figure 6.19 Floating Belt

6.4.2 Analysis of design ideas

These ten ideas were developed based on the embodied design approach. In the context of design ideation, these designs have shown that the embodied design strategies are workable, and Matrix of Schemas and Spatial Features can provide a direct and useful guide to generate design ideas about interaction with ambient media. Although the current study has not built

prototypes and conducted empirical experience tests, the possible analysis across these designs is worth doing in terms of the researcher’s self evaluation, which will provide a reflective basis for the study at next phase.

By referring to the design criteria (5.2.1), this study is to analyze the ten ideas in terms of four criteria: embodied schematic metaphor, bodily engagement, unexpectedness, public space. Based on the properties of ambient media and embodied meaning making (Figure 5.15), Table 6.2 is formulated to comprise four criteria (the first column) as guidelines for qualitative analysis (the second column). As these design ideas are targeted on different topics (except Reading Door and Book Staircase), the analysis is not to evaluate which design is better than others for a certain design problem. Rather, it evaluates whether the embodied design approach can effectively guide ideating process for ambient media design. Ten designs were analyzed as shown in the following tables, and the numbers from 1 to 3 are used to stand for the levels that the design achieves the criteria (the third column).

Criteria	Rubric for analysis	Level
Metaphorical mapping	Level 3: Embodied metaphor and visual metaphor are both constructed in the interaction process. Level 2: Embodied metaphor is constructed in the interaction process. Level 1: Visual metaphor is constructed in the interaction process.	1-3
Bodily engagement	Level 3: Participating in motor interaction through whole body Level 2: Participating in motor interaction through parts of body (e.g., arms, hands) Level 1: Observing a situation by standing, sitting	
Unexpectedness	Level 3: All strategies are involved. Level 2: Two of the strategies are involved. Level 1: One of the strategies is involved. Three strategies for triggering unexpectedness (see 5.2.1.2): 1) Contrasting input / output (I/O) relations: When the audience performs an action, the output does not match audience’s	

	expectation (e.g., Twisting the shoe results in the distortion of the building. 2) Contrasting physical and virtual elements: Digital media is embedded in the physical space, which leads to a mismatch between tangible reality and virtual reality (e.g., After the physical door is opened, digital image emerges to show the scene from another city. 3) Visual elements mismatching the content or context: (e.g., The stairs resembling the shape of piano keys elicit a surprise.)	
Public space	Level 3: The work is situated in outdoor public space. Level 2: The work is situated in indoor public space. Level 1: The work is situated in indoor semi-public space. accessibility	

Table 6.2 Analytical framework

On the other hand, based on the model of meaning making (Figure 5.18), an analytical model (Figure 6.20) is formulated to analyze embodied metaphorical mappings in the design ideations.

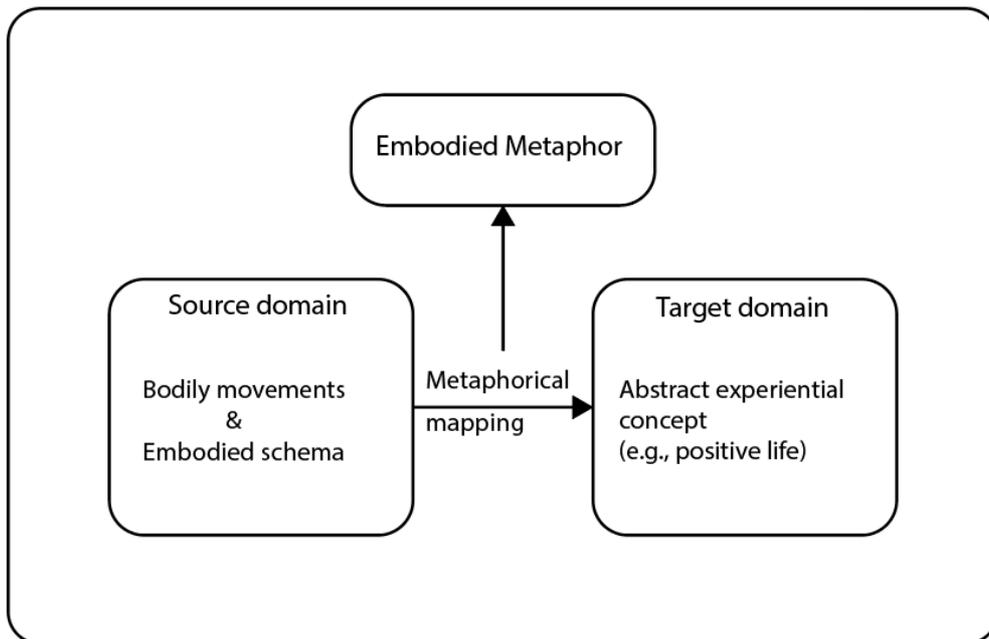


Figure 6.20 Analytical model for embodied metaphor

Compared with the previous model, this model more focuses on the mapping between bodily movement (source domain) and concept to be understood (target domain). Bodily movements, as the specific and concrete form of embodied schema, can activate the conceptual mapping between two

domains, which give rise to the embodied metaphor and generate embodied meanings. Based on the four criteria and the analytical model, the ten design ideations are analyzed as follows.

1) Analysis of Basket Trash Bin

Criteria	Analysis	Level
Idea 1: Basket Trash Bin		
Metaphorical mapping	Visual metaphor and embodied metaphor are both involved: The trash bin is designed to resemble the shape of basketball board, which construct visual mapping from trash bin to basket. The action of throwing trash (source domain) is mapped onto the experiential concept of playing basketball (target domain), which constructs the embodied metaphor that depositing trash properly through interacting with the basket trash bin.	3
Bodily engagement	Attracted by the trash bin's backboard-like design, a passerby is more likely to drop garbage to the bin rather than the ground.	2
Unexpectedness	Two strategies are used: The trash bin resembles visual features of basketball backboard. The hidden speaker plays a sound of cheer as feedback.	2
Public space	Basket Trash Bin is situated on the street and completely open public space, which makes people encounter it easily.	3

Table 6.3 Analysis on Basket Trash Bin

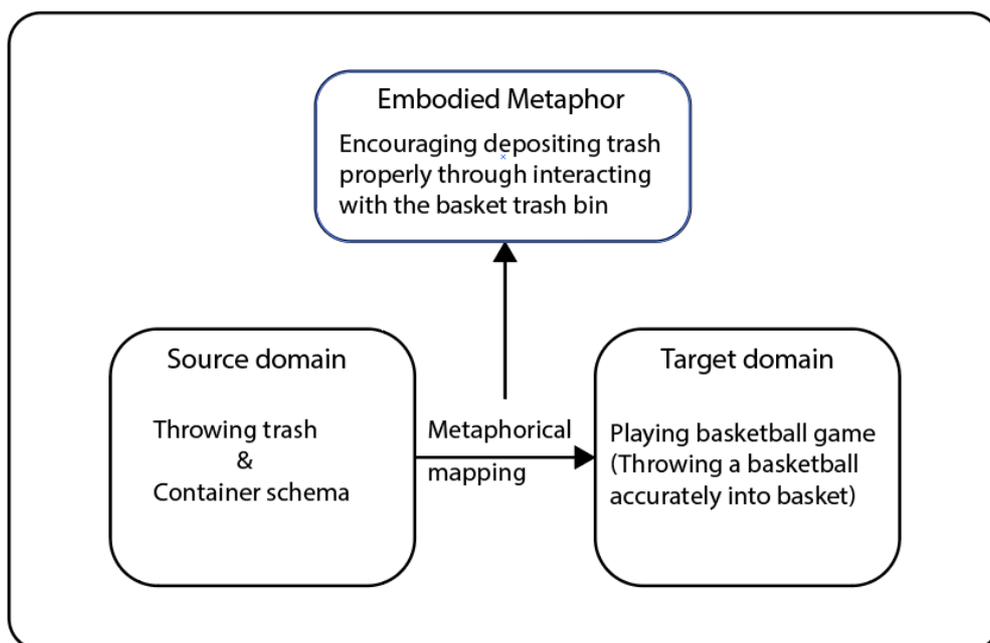


Figure 6.21 Metaphorical mapping of Basket Trash Bin

2) Analysis of Reading Door

Criteria	Analysis	Level
Idea 2: Reading Door		
Metaphorical mapping	The action of opening the door is metaphorically mapped onto reading a book, which constructs a metaphor that opening a physical space is entering a knowledge space. The door is decorated like a book cover, which is a visual metaphor.	3
Bodily engagement	Whole body is engaged in the interaction with Reading Door.	3
Unexpectedness	Two strategies are used: The door resembles visual features of a book cover. The hidden speaker plays a sound of opening book pages as feedback.	2
Public space	The entrance of the library is outdoor public space.	3

Table 6.4 Analysis on Reading Door

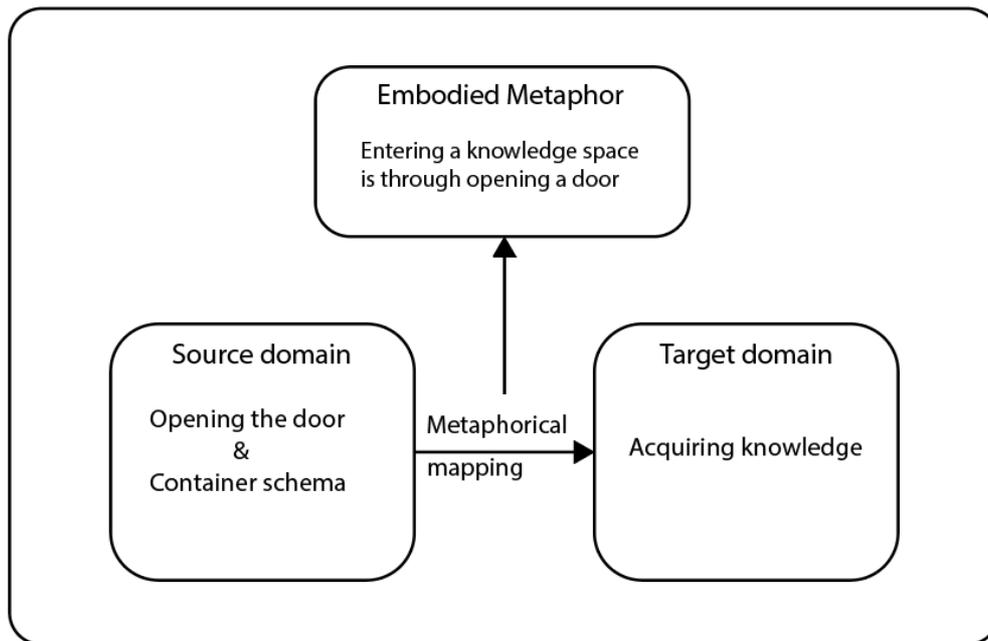


Figure 6.22 Metaphorical mapping of Reading Door

3) Analysis of Social Bench

Criteria	Analysis	Level
Idea 3: Social Bench		
Metaphorical mapping	The embodied schemas are related to Orientation (Near-far) and Unity (Link). Sitting closer in physical space is a metaphor denoting close interpersonal relationship.	2
Bodily engagement	Whole body movement: The lighting effect on the bench may motivate passersby to take a seat, and the glowing line connecting people may facilitate them to move closer to each other.	3
Unexpectedness	Two strategies are used: When someone sit on the bench alone, a light effect will appear around the person, which may give rise to surprise to people (contrasting I/O relations). The glowing line connecting people also creates unexpectedness for two sitting people (contrasting physical and virtual elements).	2
Public space	The bench is located in a park (outdoor public space), and offers the sitting affordance.	3

Table 6.5 Analysis on Social Bench

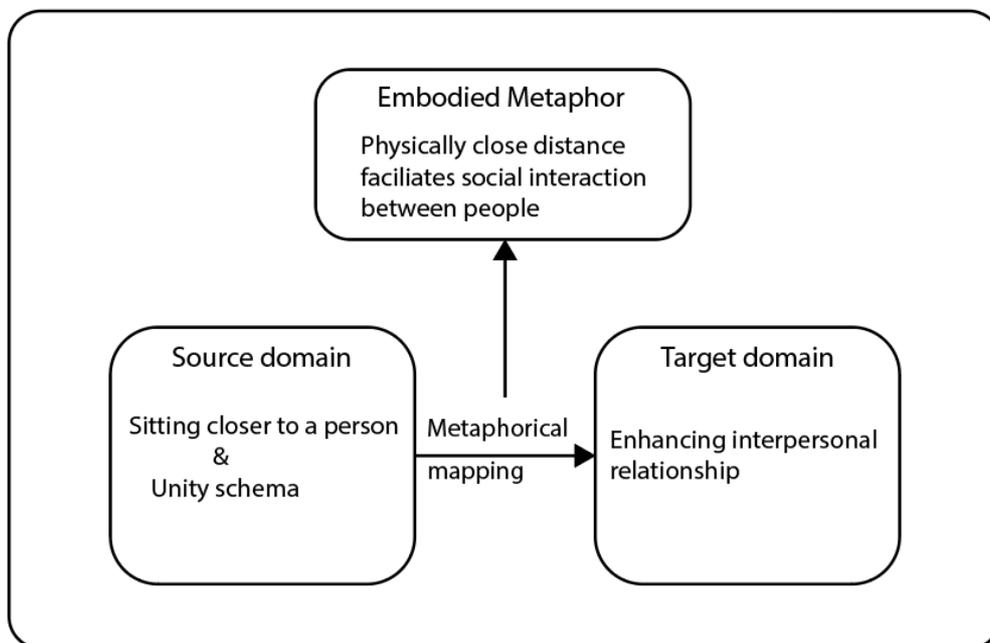


Figure 6.23 Metaphorical mapping of Social Bench

4) Analysis of Hug Pole

Criteria	Analysis	Level
<i>Idea 4: Hug Pole</i>		
Metaphorical mapping	Conceptual metaphor and visual metaphor are included: Getting closer to the pole and hugging the cushion are related to Orientation schema (Near-far). Physical warmth denotes psychological warmth (Temperature). The cushion resembles the shape of a heart.	3
Bodily engagement	The heart-shape cushion engages passersby in touching or hugging (whole body movement).	3
Unexpectedness	Two strategies are used: Warmth and lighting effect may trigger unexpectedness after the passerby hugs the cushion (contrasting I/O relations). The cushion resembles the shape of a heart (Resembling visual features).	2
Public space	The interaction happens on street (outdoor public space).	3

Table 6.6 Analysis on Hug Pole

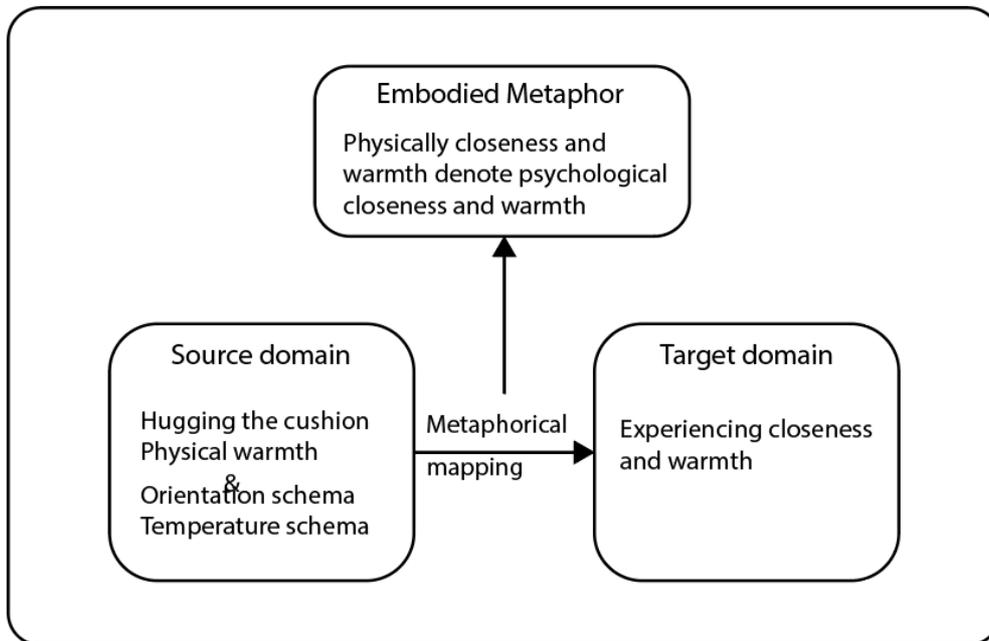


Figure 6.24 Metaphorical mapping of Hug Pole

5) Analysis of Book Staircase

Criteria	Analysis	Level
Idea 5: Book Staircase		
Metaphorical mapping	Orientation schema (Up-Down) structures the embodied meaning of knowledge increasing through walking on the staircase. The staircase resembles the shape of books.	3
Bodily engagement	The action of stepping on books is not directly related to the meaning of reading book, but the spatial level is metaphorically mapped onto knowledge amount.	3
Unexpectedness	Two strategies are used: The staircase resembling the arrangement of book may trigger surprise at first glance (Resembling visual features). When people walk on a stair, it triggers a voice reading a famous quote from a book (contrasting I/O relations).	2
Public space	It is situated in the indoor space of a library.	1

Table 6.7 Analysis on Book Staircase

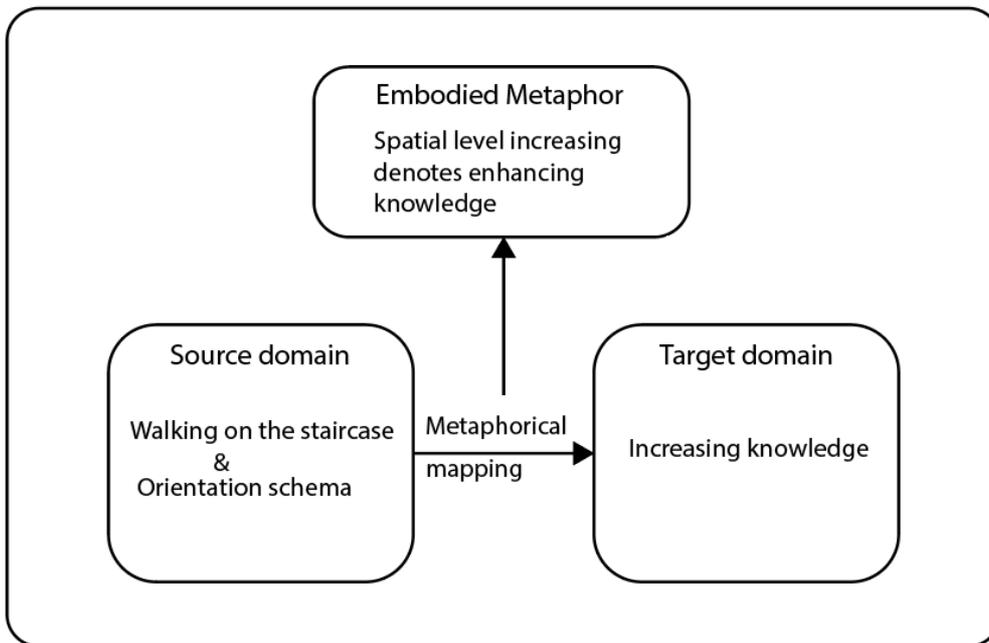


Figure 6.25 Metaphorical mapping of Book Staircase

6) Analysis of Lighting Corridor

Criteria	Analysis	Level
Idea 6: Lighting Corridor		
Metaphorical mapping	Path and Orientation (Near-Far) schemas jointly structure the embodied interactions, as walking along the corridor is following a path. The spatial distance and forward lighting metaphorically express a sense of future hope.	2
Bodily engagement	The lighting ahead of the passerby engages him/her in keeping walking forward (whole body movement).	3
Unexpectedness	One strategy is used: The lighting always appearing about five meters ahead the passerby who are walking (contrasting I/O relations).	1
Public space	The corridor is located in a public university, and people intuitively walk along it (outdoor public space).	3

Table 6.8 Analysis on Lighting Corridor

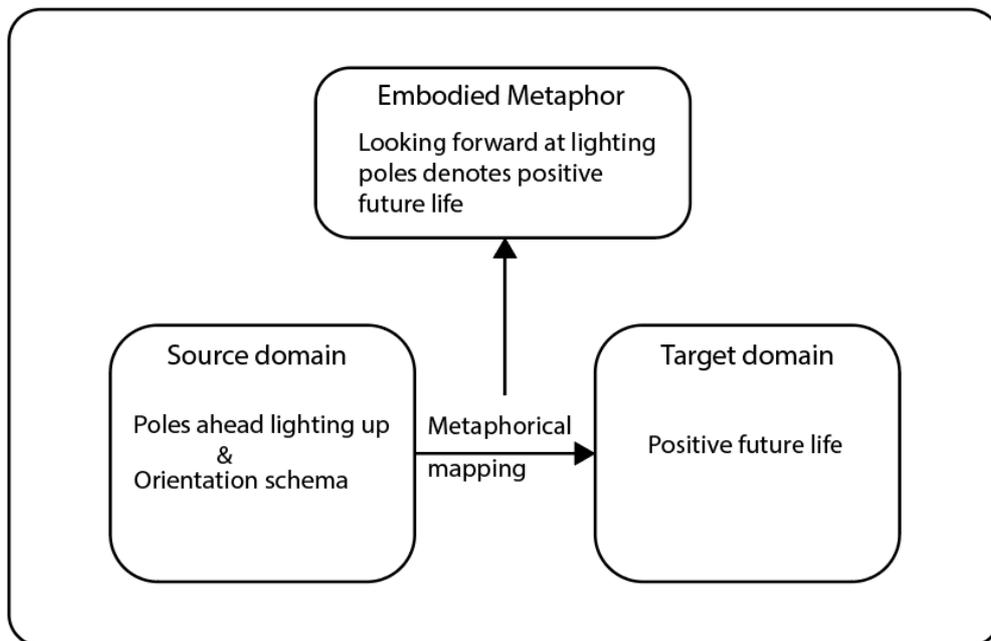


Figure 6.26 Metaphorical mapping of Lighting Corridor

7) Analysis of Water Body

Criteria	Analysis	Level
Idea 7: Water Body		
Metaphorical mapping	Container and Orientation schemas both structure meaning making in interaction with Water Body. The real-time body figure containing water embodies Container schema, and the water level declining and rising is a metaphor extended from Orientation (Up-Down) schema.	2
Bodily engagement	The passerby may change his posture to see various figure effects on the wall. Touching the cup to pour water into the body when the water level declines.	2
Unexpectedness	One strategy is used: The water level declining may lead to unexpected feelings (Contrasting I/O relations).	1
Public space	The wall is in an indoor public space.	2

Table 6.9 Analysis on Water Body

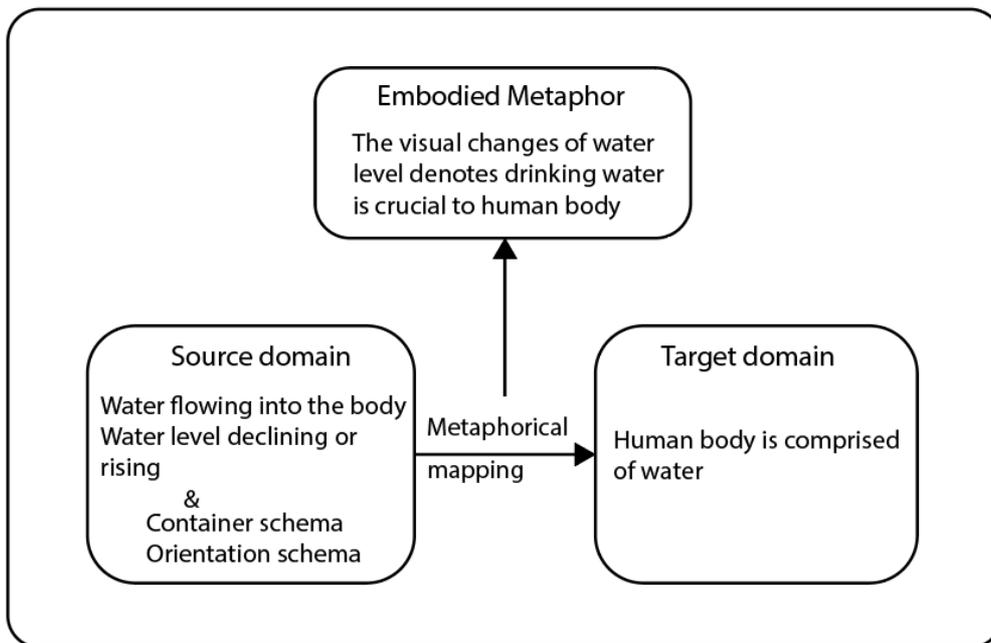


Figure 6.27 Metaphorical mapping of Water Body

8) Analysis of Smile Mirror

Criteria	Analysis	Level
Idea 8: Smile Mirror		
Metaphorical mapping	Existence (Removal) schema structures the metaphorically mapping from smiling to removing unhappiness.	2
Bodily engagement	The main motor input is facial expression changes (bodily engagement is limited to facial expression, seeing or standing).	1
Unexpectedness	Seeing the face hidden by a white mask may trigger surprise (contrasting I/O relations).	1
Public space	The location is in a public toilet (indoor semi-public space).	1

Table 6.10 Analysis on Smile Mirror

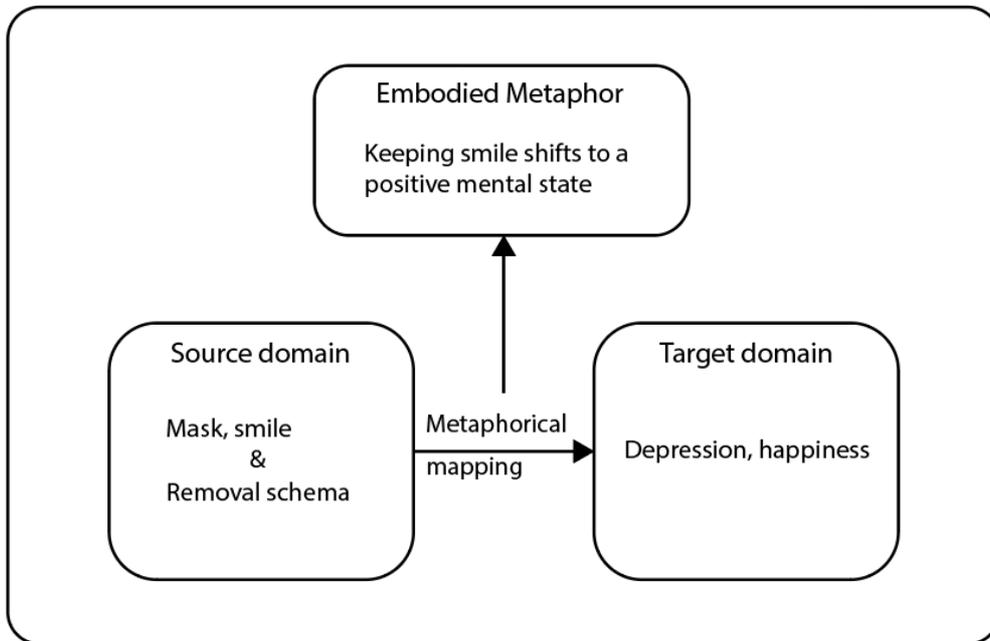


Figure 6.28 Metaphorical mapping of Smile Mirror

9) Analysis of Forest Floor

Criteria	Analysis	Level
Idea 9: Forest Floor		
Metaphorical mapping	The image schema Removal, as a source domain in this embodied metaphor, is mapped onto the target domain “destroying forest”.	2
Bodily engagement	When the audience pass the forest (whole body movement), the area around him becomes grey and looks like destroyed, and it will recover after the audience leave.	3
Unexpectedness	One strategy is used: Disappearing and recovering of the forest may give rise to unexpectedness (Contrasting physical and virtual elements).	1
Public space	It is located in an indoor public space. The floor provides the affordance of walking around.	2

Table 6.11 Analysis on Forest Floor

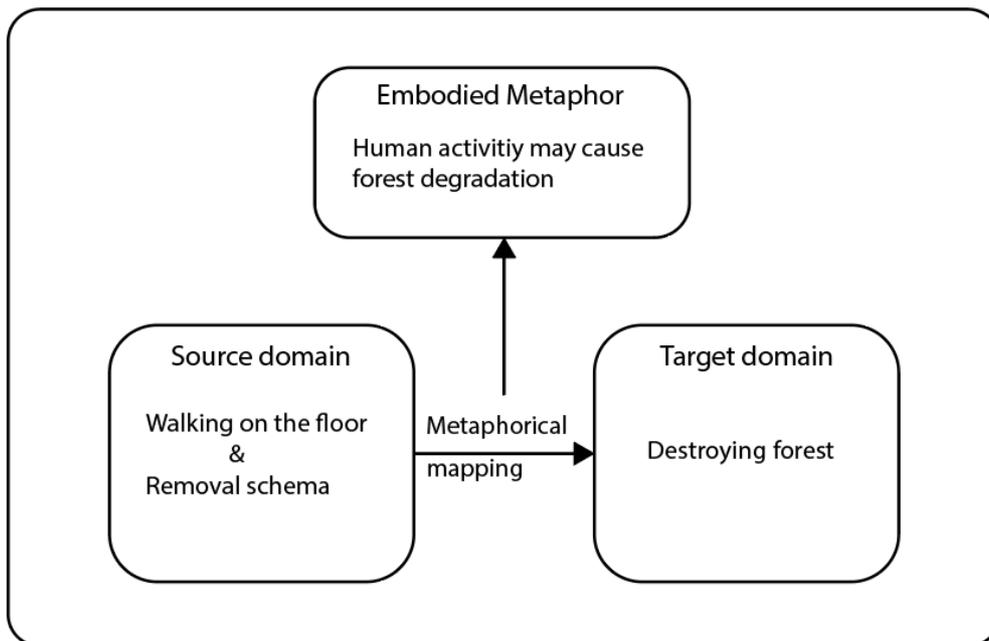


Figure 6.29 Metaphorical mapping of Forest Floor

10) Analysis of Floating Belt

Criteria	Analysis	Level
Idea 10: Floating Belt		
Metaphorical mapping	The whole interaction is related to both Path and Existence (Removal) schemas. The movement of luggage belt resembles ocean flow (visual mapping). Removing garbage by hands metaphorically expresses protecting marine environment (conceptual mapping).	3
Bodily engagement	The belt like a ocean flow and the garbage on the belt may attract passengers' attention to approach them (whole body movement).	3
Unexpectedness	Three strategies are used: After removing the garbage, beautiful fishes swimming in the ocean may lead to unexpectedness (contrasting I/O relations). The digital image (garbage) is embedded in the physical space (belt) (Contrasting physical and virtual elements). The luggage belt resembles ocean flow (resembling visual features).	3
Public space	Luggage belt is located in indoor space of an airport. The belt itself provides the affordance of displaying dynamic visual effects for interaction.	2

Table 6.12 Analysis on Floating Belt

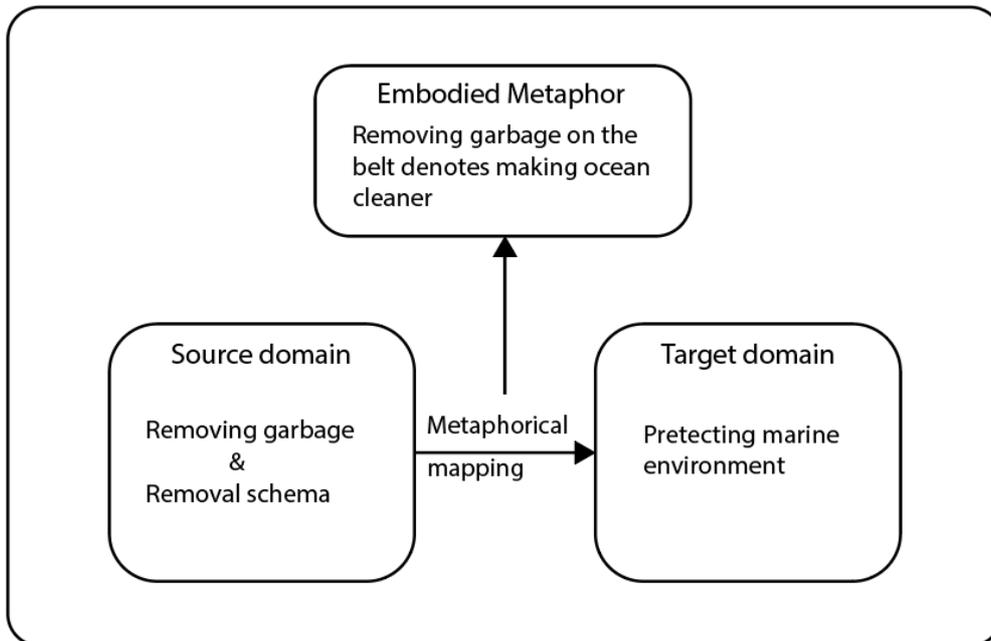


Figure 6.30 Metaphorical mapping of Floating Belt

Furthermore, above analyses are visualized as a group of bar charts (Figure 6.28) indicating their levels varying in four criteria (E standing for Metaphorical mapping, B for Bodily engagement, U for Unexpectedness, P for Public space).

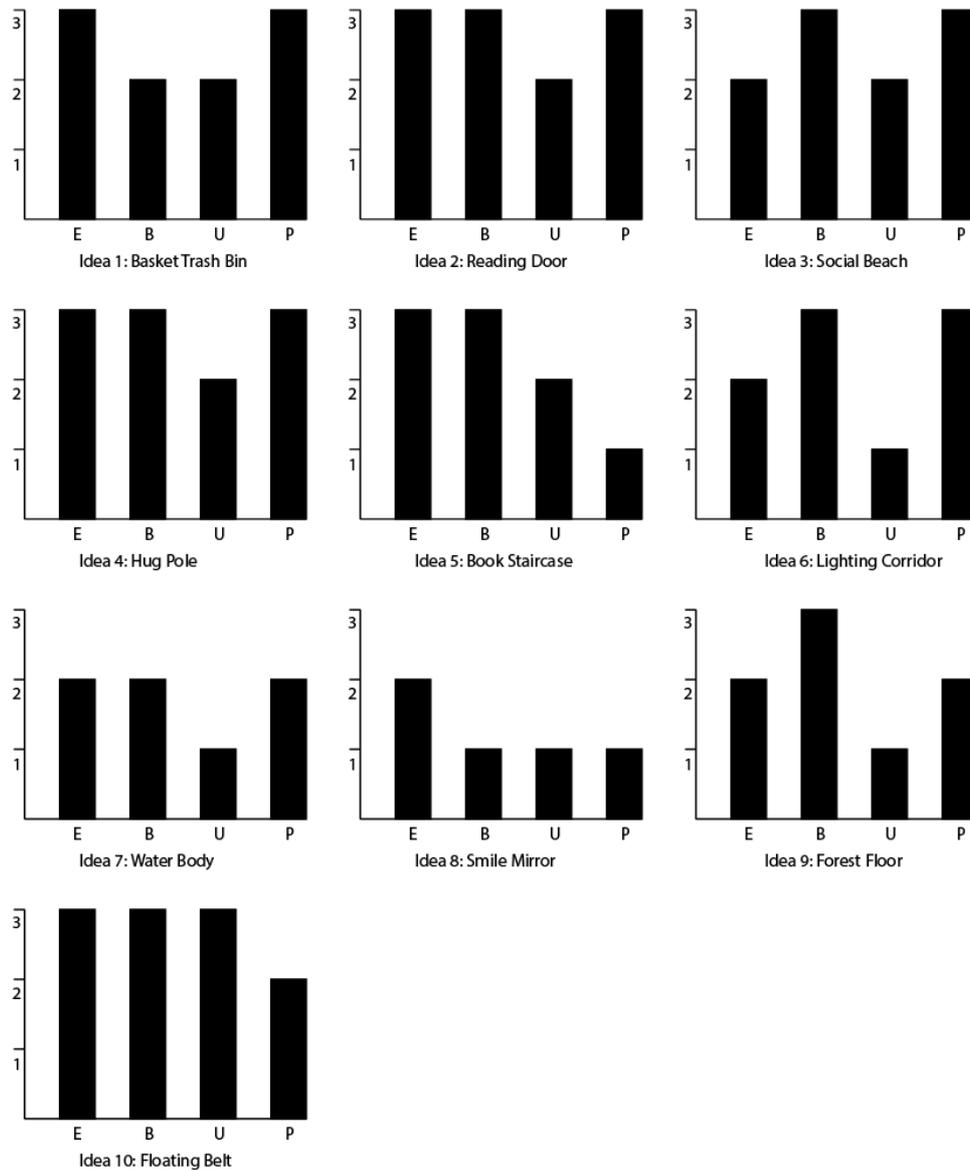


Figure 6.31 Overall analysis of design ideations

As these designs have different topics and scenarios, the comparison is not to judge which idea is best, but to discuss whether the embodied design approach is workable for generating design ideas. Idea 2 Reading Door, Idea 4

Hug Pole and Idea 10 Floating Belt have similar pattern, as three criteria are level 3 while one is level 2. They all engage people's whole body actions, while visual mapping and conceptual mapping both contribute to embodied meaning making. Bodily movements, as a concrete embodiment of image schema, activate metaphorical mapping from source domain to target domain. In *Reading Door*, the action of opening the door, as the source domain, is mapped onto the target domain opening (reading) a book or entering a world of knowledge, which is structured by Container schema. The action of opening the "book" is congruent with the feedback of seeing on the quote on the white board (page). *Hug Pole* has active bodily engagement by affording hugging actions, and temperature feedback (warmth) accords with the motor input and the embodied meaning.

Idea 6 Lighting Corridor and Idea 9 Forest Floor have same levels in first three criteria. They only use conceptual metaphor: The spatial distance and forward lighting metaphorically express a sense of future hope, and walking on the floor (forest), as a source domain is mapped onto the target domain "destroying forest". They engage people's whole body movements. One strategy for eliciting unexpectedness is used: The lighting always appearing about five meters ahead the passerby who are walking (contrasting I/O relations). Disappearing and recovering of the forest may give rise to unexpectedness (Contrasting physical and virtual elements).

Idea 7 and Idea 8 have similar pattern. Metaphorical mappings in *Water Body* and *Smile mirror* are embodied well and explicitly, but bodily actions are not actively engaged. They contrast I/O relations for eliciting unexpectedness.

The above analysis indicates that the embodied design approach is applicable for generating design ideas toward embodied interactions with ambient media. Although the approach has not yet been integrated as concrete design

guidelines, four design strategies and matrix of schemas and spatial features have shown that they can effectively guide ideation process. The next study phase is to prototype a design idea and conduct experience tests to empirically investigate audience experiences and embodied interactions by applying the unified model of embodied engagement (Figure 6.1), which is expected to further validate the embodied design approach.

6.4.3 Experience prototyping and design evaluation

Based on the model of embodied meaning making and theoretical framework, the above interpretive analyses show how these designs can elicit meaningful and engaging experience at various levels. As these analyses are from the researcher's perspective, empirical evaluation is needed to triangulate the proposition, which also offers a way to validate and strengthen the previous studies. This section articulates an empirical study on evaluating audience experiences with an ambient media work developed from above ideations.

6.4.3.1 Prototyping Reading Door

As discussed in Chapter 3, after investigating embodied audience experiences with ambient media through interpretive and empirical studies, this research aims to explore how these findings can help designing embodied interactions with ambient media by drawing upon the methodology of Research through Design. Although interaction design ideations, usually as a form of sketch or diagram, are generated based on human embodied experience, they are merely conceptual ideas. Prototyping is a unique means to create possibilities for understanding how people actually experience a situation by viewing, touching, hearing, even smelling and tasting various attributes of an artifact such as materials, graphics, shapes, spatial relations (Koskinen et al., 2011, pp. 134-136). Experience prototyping is a type of prototyping that can help designers and users to get real experience in a simulated situation by directly interacting with the prototype (Buchenau & Suri, 2000). In this study, the goal

of prototyping is to provide an authentic situation for evaluating the embodied design approach by creating a physical interactive ambient media work based on the ideations.

Based on these design ideations, this study chose *Reading Door* for experience prototyping. According to the analysis (Table 6.4), this idea ideally accords with four criteria: The door in a public space is transformed as ambient medium to engage people in bodily interaction, which elicits unexpected responses. The action of opening the door metaphorical expresses the meaning of reading a book (entering the space of knowledge). The meaning making is mainly structured by Container schema. In order to empirically understand how people experience *Reading Door* and evaluate these conceptual analyses, a door in a public space of a university was employed the physical basis to build prototype.

Technically, there are four considerations for building the physical work:

- 1) The door was decorated resembling a book cover, which aimed to create visual mapping.
- 2) A sound of turning book pages is played simultaneously when the door is turned.
- 3) A bookshelf was placed in the room, and books were also prepared.

As shown in Figure 6.32, the physical prototype was installed in an interior public space of a university building. An acrylic board with book cover printing was mounted on the door surface. A sensor was embedded to detect the state of the door.



Figure 6.32 Prototype of Reading Door

6.4.3.2 Experience tests

After setting up the prototype, experience tests were carried out by inviting participants to experience the Reading Door. The tests aim to collect empirical data for understanding audience's embodied experience in terms of metaphorical mapping and attributes of ambient media. We invited 15 participants (6 males and 9 females) to experience the prototype. All participants were invited from a university in Hong Kong. Their ages were from 18 to 37. Eight were Chinese from Mainland China, five locals, one American, and one Malaysian.

Procedures

1) Preparation session

After the prototype is installed, the researcher tests it for technically working well. Then, 15 participants recruited from PolyU campus joined the experience tests. Before interacting with the door, they were informed that they were supposed to enter a library to borrow a book, and they can pick up

one book that most interests them, and the main aim of this experiment was to understand their experience about borrowing book. They needed to sign a consent form (see Appendix 1) which indicated that their behaviors might be recorded as video or photo.

2) Interaction session

A participant can enter the room through the door, and the interaction process was videotaped by a camera which was hidden to reduce distraction to participants. The researcher would not give specific instructions or interrupt participant's engagement. The interaction process had no time limitation, and the participant could choose to end the experience at any time.

3) Interview session

After the interaction session, the participant was immediately asked to join a face to face interview. The first author as interviewer asked open-ended questions (Table 6.13) to allow participants to express their feelings and thinking about whole interaction process. The dialogues were audio-recorded for data analysis, and the interview was expected to last ten minutes. Interview questions were prepared based on the theoretical framework of designing embodied interactions with ambient media. The first question is intended to warm the interview up and not directly related to the framework. The overall goal of interviews was aimed to allow participants to express verbal reports reflecting their primary experience.

Components of interpretive Questions framework	
It is not directly related to the framework but for warming up interviews	Why do you choose this book?
Unexpectedness Visual metaphor	What was your feeling when you first see the library?

Embodied metaphor	Have you seen anything special? Can you talk more about this?
Bodily engagement	
Unexpectedness	How did your feel and think when opening the door?
Embodied metaphor	Have you heard anything? What did you think?
Embodied metaphor	Can you talk a little more about your feeling and thinking?
	Have you imagined anything else?
	Have you experienced similar scenes before?
	What was overall feeling about entering the room?

Table 6.13 Interview questions

6.4.3.3 Data analysis

Compared with the analysis on experience with Piano Staircase (5.3), the analysis procedure in this study focuses on investigating embodied metaphorical mapping in interacting with Reading Door, as the major objective is to empirically evaluate whether the proposition that embodied design thinking (e.g., matrix of schemas and spatial features) can effectively guide designing meaningful experience. Therefore, the analysis mainly follows a deductive approach to interpret meanings from verbal reports by applying an existing coding scheme. The coding scheme (Table 5.4) with twenty codes was generated from a more extensive perspective to understanding audience experiences with ambient media, and this study derives five themes (Table 6.14) for thematic coding by regarding the analytical framework (Table 6.2).

Themes and codes	Descriptions
Public space	
Spatiality	Describe spatial features or the environment
Unexpectedness	
I/O relations	Unexpected feedbacks triggered by actions
Mismatch	Mismatch visual elements and context
Engagement	

Bodily movements	Observed and described bodily movements
Cognitive experience	
Anticipation	Expect a certain feedback or result before acting
Evaluation	Make an appraisal of participant's experience or compare it with other things
Imagination	Associate the experience with other scenarios or concepts
Metaphorical mapping	
Embodied metaphor	Project bodily interaction on to other concepts or expressions
Visual metaphor	Project one object on to another object in terms of the visual similarity

Table 6.14 Five themes

The procedure for analysis comprises four progressive stages: Firstly, the audio data containing participants' retrospective reports is transcribed as text files, which are imported into HyperResearch (see 5.2) for coding. Then, the researcher analyzes the verbal reports by assigning the codes (Table 6.14) to phrases or sentences. Finally, after finishing coding, all reports were reexamined, compared, and grouped for summarizing results.

6.4.3.4 Results

The thematic analysis gives rise to a series of results in terms of the five themes.

1) Metaphorical mapping

Visual mapping

When being asked about their first impression of the library, many participants immediately associated the door with a book cover: "I felt it is like a book in front of me" (P4). "The door's color is very lively and attractive, and it looks like a huge book with the title and author name" (P7). "When I was outside, the colors and words "written by" remind me of classic books 1980s and 1990s. They have yellow book covers. It is modern classic." (P11).

Meanwhile, a few mentioned other objects such as poker card and poster, and some others said they did not notice the details on the door.

Embodied mapping

Many participants described various embodied mappings between bodily movements and metaphorical concepts. Many participants said they felt pulling the door is like turning over a book cover or entering a space of information (knowledge): “After turning over the door, I heard a sound like turning pages. I felt it was like reading a book. I was surprised” (P3). “Compared with common doors, it made me felt be ready to enter a magical world” (P4). “I heard a sound like flipping book when turning the door. This reminds you that you are going into a book” (P12). “I felt that the door was like a critical point, and I was entering a knowledge space after opening the door” (P7). “The door is a medium separating two spaces, and it is like an entrance to a book world” (P8).

2) Engagement

Bodily movements

Despite not being directly asked to talk about bodily engagement, most participants described their bodily states at different moments. When the researcher asked their feelings of entering the room, they mentioned bodily actions using proactive words (e.g., open, turn, pull the door, and go into, walk in, enter the room). For example, P1 mentioned: “When I opened the door, I simultaneously heard a sound like flipping paper.” P7 said: “When pulling the door, I noticed it made a sound and then saw the books on the left.” Figure 6.33 shows some examples about their bodily actions of entering the room.

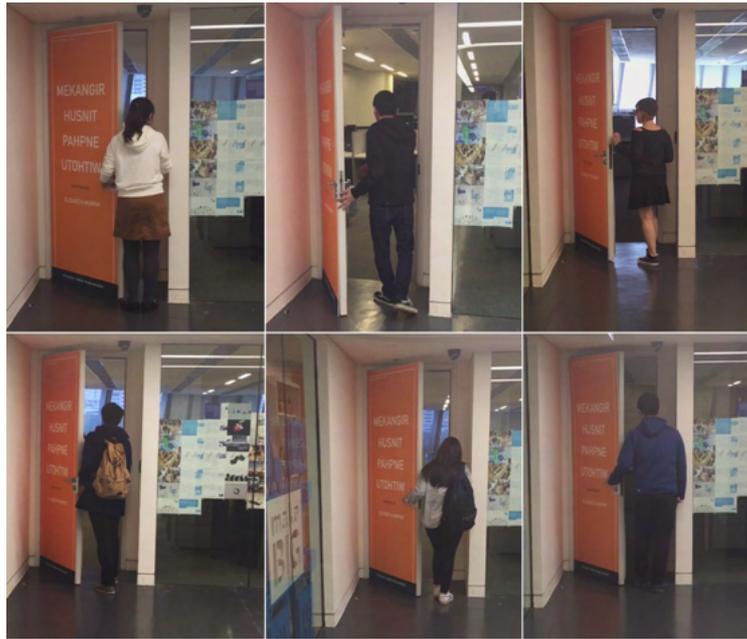


Figure 6.33 Bodily engagement.

3) Unexpectedness

Various expected feelings described by some participants mainly embody in two aspects: mismatch between the appearance and the context, unexpected feedback. Firstly, when being asked about the impression of the library, many participants expressed they had a surprise feeling when seeing the door at the beginning of the experiment. P5 said: "I think it is very prominent, and the color of the door is warm and attractive to me." P10 mentioned: "At my first sight of the door, it looked like lively, energetic, mysterious. After a while, I started to realize that it was like a huge book" P9 described: "When I first saw the library, I felt its door was colorful and special." Second, some participants mentioned they were surprised by the sound triggered by the action of opening the door. For example, P4 described: "I felt surprised and pleased, and compared with common doors, it made me felt be ready to enter a magical world."

4) Public space

Spatiality

Physical features of the space were mentioned by many participants. Four of them described the door as a boundary separating two spaces. For instance, P7 thought that the door was an entrance to knowledge, and when going out from the room, he felt being out of the knowledge space. P10 also mentioned: "The book-like door is a medium separating two spaces, and it is like an entrance to a book world."

5) Cognitive experience

Many participants constantly anticipated, evaluated, and imagined during interaction process.

Anticipation

The participants had various expectations before they entered the room. P4 described: "I very expected something, and I imagined that whether the things inside had same feelings as the door." P7 mentioned: "I was curious about it, and started to imagine what the inside should be, and many rows of bookshelves." P8 said: "I expected that the inside setting should be similar to the design of outside (lively feeling)." "If I can see something, I may have some expectations about next step" (P13).

Evaluation

According to their anticipations, participants also evaluate their experience, especially after they went into the room. Many participants described the overall experience was positive (interesting, fun, exciting). P2 said: "It was very interesting and lively, and I think it also brought mysterious feeling to me." P12 said: "I like it should be very fun if the design is for a children library." P15 said: "I thought it is interesting and made me feel pleased." Some also expressed some aspects that did not match their expectations. P13 mentioned the door when he was outside of the room: "The color is very bright, but the wording was not make sense to me." "The inside space should

be dark, but there is only one shelf, and the light is too bright” (P1). “I think it lacks a procedure of borrowing” (P9).

Imagination

Some people associated their immediate experiences with other scenarios and concepts. For example, P7 described the door was like a box, or gift box, music box, as he had a music box in his childhood, and it can play music when opened. Opening the door reminded him of this feeling, as the sound was a little bit like opening the box. P12 imagined: “That’s why it relates very well to children’s library where on the front, there is a sleeping beauty when going in, the pages are flipping. and inside it’s like a magic world adventure.” P6 said: “Overall, it is very similar to the books published by Penguin.” P9 described: “I heard a sound when turning the door. It is like an action triggering a certain mysterious machine.”

6.4.4 Discussion

The qualitative findings from experience tests and data analysis resonate with the prior empirical study on audience experiences with *Piano Staircase*, and this also indicates that the embodied approach is applicable for designing embodied interactions for enriching experience with ambient media. This section discusses three closely intertwined relationships: metaphorical mapping-bodily interaction, embodied schema-spatial feature, and unexpectedness and sensory perception.

6.4.4.1 Metaphorical mapping is constructed by bodily interactions

The data analysis shows that metaphorical mapping is constructed in people’s bodily interaction. This substantiates the viewpoint that cognitive experience is grounded in interaction with physical environments, and it inherently involves real-time sensory-motor engagement (Wilson, 2002). Although many participants said the door looked like a book at the beginning of experience,

their descriptions are limited to the perceptual resemblance in visual features (e.g., shape, color, text), but not related to conceptual meanings (e.g., reading a book) as in the ideation assumed by the researcher. However, when they talked about the experience in interacting with the door, their descriptions reflect various embodied mappings from bodily actions to metaphorical concepts, and metaphorical meaning making is closely tied to bodily states. This exactly resonates the analysis in the model of embodied meaning making (Figure 6.15). The immediate bodily action of opening the door serving as the source domain in the metaphorical mapping is mapped onto target domain entering a book (acquiring knowledge), and the mapping between two domains constructs the embodied metaphor: Entering a knowledge space is through opening a door. The metaphor is structured by the embodied schema Container, which is a recurrent cognitive pattern formed in people's long-term bodily experience with various spatial relations. This research argues that the metaphorical mapping in experience with ambient media is constructed through real-time bodily interaction, and people's everyday experience is enriched in the process of constructing embodied metaphor.

6.4.4.2 Embodied schema and spatial feature

As introduced in the theoretical background, spatiality is one of the properties of ambient media. Facilitating meaningful experience with ambient media is a process that audience engage in sensory-motor interactions with the mediated physical space. This proposition accords with the view of embodied cognition that people's cognitive work is off-loaded to the environment for increasing cognitive processing (Wilson, 2002). Interacting with ambient media takes place in real public space, and audience's bodily actions are modulated by the affordances of physical spatial features (e.g., the door offering possibilities for opening and entering). The ideation of Reading Door was inspired by people's everyday actions: opening a door and entering a room that is one of phenomena embodying Container schema. The actions of

opening a door and opening a book have the similar embodied schematic structure, as they are in line with the characteristics of Container schema: a boundary divides an interior space and an exterior space. Container schema emerges from the recurring structure that people's bodies constantly and unconsciously perform various activities (e.g., putting food into mouth, going into or out of a room) involving clear-cut in-Out orientation (Johnson, 1987; Lakoff & Johnson, 1980). Embodied schemas are closely interwoven with ongoing spatial interactions, and "directly meaningful, experiential, and embodied" (Gibbs, 2008). The present experiment empirically validates that the matrix (Table 6.1) of linking embodied schematic structures with the physical affordances of spatial features is an effective mean in designing embodied interactions for enriching meaningful experience.

6.4.4.3 Unexpectedness and sensory perception

Unexpectedness is regarded as a key experiential factor in experience design (Hutter, 2015; Liang, 2012). The thematic analysis also indicates that eliciting unexpected responses can motivate people to engage in interaction with Reading Door. Two design strategies: mismatching visual elements and context, creating unexpected feedback were used in designing Reading Door. Firstly, the former one refers to the visual elements (e.g., shape, color) of the space resembling another object out of the current context (e.g., a door designed like a book, a staircase designed like a piano). The door was visually designed like a book cover, and many participants felt surprised by the book-like door at the first sight. Furthermore, eliciting unexpectedness can facilitate participants' anticipation. Five participants (P1, P4, P7, P8, P10) said he very expect to see what the inner space looked like, after they were surprised by visual appearance of the door. The second strategy for designing unexpectedness is that the sensory feedbacks triggered by bodily actions mismatch audience's expectation. For instance, some participants described that they felt surprised by the sound of flipping pages when opening the door.

The sound is unexpected but reasonable, as it amplifies the target domain (reading a book) of the embodied metaphor. When audience encounter ambient media, sensory clues not only provide affordances for bodily actions but also elicit unexpected responses and facilitate cognitive engagement. Unexpectedness is not only a property of interaction with ambient media, but also an important strategy in enriching audience experiences and engaging embodied interactions.

6.4.4.4 Design principles

Based on the discussion on above relationships, we propose three principles for designing embodied interactions with ambient media.

- 1) Aligning bodily interaction with metaphorical mapping: Bodily interaction activates the metaphorical mapping from immediate action (source domain) onto a conceptual meaning (target domain), which is the most important consideration in designing ambient media.
- 2) Linking embodied schematic structures with spatial features: The physical affordance of a space is inherently in with a certain embodied schema. The spatial features inform audience to perform certain bodily actions, which facilitates constructing an embodied metaphor that is structured by an embodied schema.
- 3) Designing action-perception (Input-Output) relations for eliciting unexpectedness and facilitating metaphorical mapping: The sensory feedback triggered by bodily actions may not accord with the current context (source domain), but be congruent with the target domain of the metaphor.

6.5 Summary

This chapter proposes an embodied approach to designing ambient media by consolidating the findings from both preceding studies and the study on designing ambient media. This study focusing on exploring ambient media

design is mainly comprised of three progressive stages. The design workshop as a pilot study was conducted to gain initial understanding on how the design strategies derived from the embodied models can guide ambient media design. Then, a matrix coupling embodied schemas and spatial features was developed based on the pilot study and previous findings, which provides a useful thinking tool for linking bodily action with embodied meaning. In the third stage, the research applied the approach to ideate a range of design ideas and analyzed them in terms of three properties of ambient media and metaphorical meaning making. Prototyping and experience tests on Reading Door were conducted to evaluate the interpretive analysis on the design idea, and qualitative data on participants' verbal reports was analyzed in regard to the coding scheme of audience experiences. The discussion focused on three closely interwoven relationships between various experiential aspects. The findings show that the approach is applicable for designing embodied interactions with ambient media toward enriching meaningful experience. Three design design principles were also presented based on the discussion.

As this study focuses on the ideation, design, and evaluation of one case, empirical work on more cases is needed. Another limitation is that the experiment was conducted in a university building, and the participants were from similar background. This may affect the results that should reflect the experience of more general population. Future work will explore more possibilities of the embodied approach in other types of spaces, and involve people from more diverse background.

Chapter 7. General Discussion⁴

7.1 Introduction and overview
7.2 Discussion on understanding audience experiences
7.2.1 Reflection on the findings from the case analyses
7.2.2 Reflection on the findings from Empirical Study 1
7.3 Discussion on designing embodied interactions
7.4 Implications for research and design
7.4.1 Implications for research
7.4.2 Implications for design
7.5 Summary

7.1 Introduction and overview

This discussion chapter focuses firstly on interpreting and reflecting upon the major findings from the preceding studies with regard to the research questions and objectives. Following this, the findings are discussed and compared with other related studies and theories, with the aim of providing suggestions and implications for further research.

Research Questions	Research question 1		→	Research question 2	
Objectives	Understanding and interpreting			→	Designing and evaluating
Major Findings	Theoretical framework	Analytical model Audience experience model		Embodied meaning making model Engagement model	Design strategies Matrix of schemas and spatial features
Studies	Theoretical study	→	Case study	→	Empirical study 1 → Design experiments (including empirical study 2)

Figure 7.1 Evolution of the approach

⁴ Parts of the author's own paper "Tan, L., & Chow, K.K.N. (2018). An Embodied Approach to Designing Meaningful Experiences with Ambient Media. *Multimodal Technologies and Interaction*, 2(2), 13" are included in Chapter 7. Longer sentences, phrases, and paragraphs are referenced.

Figure 7.1 depicts the evolution of the embodied approach that reflects the relationships between the findings, the research questions, and the objectives. Guided by the research questions: 1) “How can audience experiences with ambient media be understood from an embodied cognition perspective?” and 2) “How can a design approach be developed to support embodied interactions with ambient media?”, three progressive studies were conducted to investigate audience experiences and explore an embodied approach to the analysis and design of ambient media. Accordingly, the overall research process is summarized in two main parts: understanding and interpreting, and designing and evaluating. Each part is concerned with addressing the related research questions and achieving specific objectives (see 1.2).

In order to investigate embodied experience and identify the major factors of audience experiences in interacting with ambient media, this research first analyzed ten ambient media works to gain preliminary understandings of four experiential aspects of audience experiences in terms of embodied meaning making. This produced preliminary findings including the model of audience experiences and the typology of ambient media. Following this, an in-depth empirical study was conducted to investigate the mechanism between bodily engagement and meaning making in interactions with the interactive prototype Piano Staircase. The main characteristics of embodied experience were also identified through experience tests and thematic analysis. The empirical study produced three models of embodied meaning making and engagement, which provided useful analytical tools and guidance aimed at understanding embodied experiences.

In addition, design strategies derived from the empirical study were applied to conduct a pilot study on designing ambient media works, and then a matrix reflecting the relationship between embodied schemas and spatial features

was created. Guided by the design strategies and matrix, the author of this thesis, acting as a designer, conducted design experiments and developed ten design ideas. Based on an analytical model of embodied metaphor, the ten ideated designs were analyzed for evaluation. Furthermore, experience tests on the prototype of Reading Door provided empirical evidence to support the analysis of the design ideas. This study of designing and analyzing ambient media works consisted not only of a process of developing an embodied approach but also validating the approach by applying the analytical models (e.g., embodied meaning making model) and findings (e.g., coding scheme) from Empirical Study 1.

Overall, the two research questions were answered through these progressive studies on understanding and designing embodied experiences with ambient media, which subsequently offer a basis for reflecting on the theoretical and methodological contributions and implications.

7.2 Discussion on understanding audience experiences

The above overview indicates that understanding audience experiences is essential to designing embodied interactions. This section concentrates on reflecting on the findings regarding understanding and interpreting the audience experiences, which were primarily yielded from the case study and Empirical Study 1.

7.2.1 Reflection on the findings from the case analyses

The audience experience model (Figure 4.11) and typology of ambient media (Figure 4.12) were formulated based on case analyses. Although preliminary, the model of audience experiences theoretically reflects the properties of ambient media and the sense-act mechanism of radical embodied cognition (see 2.3.2.1). Firstly, affordances embody the physical property of spatiality,

and the perceptual relationship between the audience and spatial features in public space. Passersby may perceive the affordance from the public environment, where their bodily actions are elicited to interact with ambient media, and embodied meaning is created from this active engagement process. Despite the facial expressions in the videos of cases potentially indicating feelings of surprise, this experience model does not intend to arbitrarily emphasize the property of unexpectedness without the support of empirical data. Secondly, the relationship between affordances and bodily actions reflects the view of embodied perception on the sense-act mechanism. Enactive perception rejects the view of perception as an internal representational process, but believes that perception mutually works with action to construct perceptual understanding (Dawson, 2013, p. 222; Merleau-Ponty, 1962, p. 157). The sense-act mechanism also embodies the fact that the tight relationship between the body and its situated environment, and embodied meaning (cognition and experience) is formed in a loop such that perception is to perceive the world through the acting body, and the body acts depending on that perception (Wilson, 2002).

In addition, the preliminary finding regarding typology offers a perspective for analyzing experiences with ambient media. The classification designated between bodily action and less bodily action may promote a hypothesis that the works without digital feedback engage the audience's bodily actions less, with regard to the fact that the three cases on the right side all involved no digital technology rather only physical interaction. As the central topic of this research does not focus on digital technology, future studies will deal with this issue of digital feedback and bodily action. The classification of visual mapping and embodied mapping implies that the possibility exists for combining both visual metaphors and embodied metaphors in designing embodied interactions with ambient media. As mentioned in the case analyses, although less generated from bodily actions but rather more concerned with

perceptual response, visual metaphor is closely related to perceptual affordance and plays an important role in attracting the audience's attention. Moreover, the case analyses also indicate that more than one schema may be involved in constructing embodied meaning making in a case. For example, in the case of Moments of Warmth, two embodied schemas, Container and Link, jointly contribute to the embodied metaphorical mapping: Entering the shelter and joining hands expresses solidarity, security, and warmth.

Given that the case analyses are based on a less rigorous analytical model and less empirical evidence, the findings are less rigorous but provide useful guidance for further investigations of audience experiences.

7.2.2 Reflection on the findings from Empirical Study 1

The major findings from the empirical study on Piano Staircase include the coding scheme, the model of embodied meaning making, the embodied engagement model and the unified model of audience experiences.

7.2.2.1 Coding scheme

Firstly, a thematic analysis of the interview reports resulted in the coding scheme containing six themes (see 5.3). The coding process was based upon a hybrid deductive and inductive analysis. Inductive analysis complemented and strengthened the existing theoretical framework by directly deriving coded categories from the transcribed reports, thereby, rendering the understanding of audience experiences more holistic and contributing new knowledge regarding embodied experiences in the context of ambient media. For example, the codes such as forceful feedback and imagination were generated from the text data. All six themes were deductively organized based on the categories of the prior coding template, and this deductive analysis offered a way of empirically substantiating the theoretical framework. One possible limitation of this thematic analysis was that only one coder (the

researcher) analyzed the material rather than employing peer checking, as qualitative research should seek alternative interpretations of the coding reliability (Fereday & Muir-Cochrane, 2006). However, it is argued that intercoder analysis does not make codes objective, as one coder subjectively trains another coder to code a small part of the material in the same manner as she or he does (Vaismoradi et al., 2013). Prior to the study, a coding scheme was developed to analyze interactive art experiences in museums (Bilda et al., 2006), including seven groups of codes (e.g., observed actions and conceptual), which are to some extent relevant to the coding scheme of this research. However, Bilda et al.'s scheme was primarily generated from the analysis of video data containing audience's bodily actions in experiencing interactive artworks, and audience's bodily actions occur within a limited area (in front of the projection or screen) due to the digital image or audio as the main media forms. In comparison, the coding scheme of Empirical Study 1 focused on analyzing bodily engagement in public space, and may therefore provide useful guidance to further relevant studies on analyzing experiences with interactive mediated spaces.

7.2.2.2 The model of embodied meaning making

The model of embodied meaning making (Figure 5.15) is a major finding that provides a lens through which to understand audience experiences and embodied interactions. The six lines specify how meaning making in interactions with ambient media arise from an embodied metaphorical mapping that is triggered by immediate bodily action and structured by embodied schema, and the mapping facilitates further conceptions about other scenarios or ideas not present in the current space. This model substantiates and extends the existing ideas concerning embodied schemas (Antle et al., 2009; Hurtienne & Israel, 2007; Van Rompay & Hekkert, 2001) and metaphorical imagination (Gibbs, 2005, 2008). Antle et al. present a model describing how embodied metaphorical meanings are extended from

the embodied BALANCE schema through bodily interactions with interactive environments, which mainly focuses on investigating the metaphorical mappings between bodily movements and musical concepts. Hurtienne and Israel (2007) propose the idea of image schemas' metaphorical extensions, which is actually consistent with the meaning of embodied metaphor. They apply this theory to design interactive screen-based interfaces to support intuitive interaction. Embodied schemas theory is also employed to understand meaning expressions in product design (Van Rompay et al., 2005), and it is proposed that people's understanding of the expressive features of a product is grounded in embodied spatial relations to the environment. Gibbs (2005) argues that imaginative activities unconsciously emerge from and are structured by recurrent patterns arising from repeated experience. The embodied meaning making model is consistent with these previous findings on embodied schema and embodied metaphor. More importantly, this model advances the understanding of embodied meaning making in interactions with ambient media by consolidating the mechanisms of past bodily experience (offline), embodied schema and immediate bodily actions (online), and embodied metaphor, as well as embodied imagination.

7.2.2.3 The embodied engagement model

The third finding regarding understanding audience experiences is the embodied engagement model (Figure 5.17). This model reflects the underlying relationship between the experience dimension and engagement phases, and indicates that the ability to engage an audience depends on the extent to which the ambient medium provides corresponding affordances to facilitate embodied interactions. The model also resonates with relevant HCI research on engagement and experience (Bianchi-Berthouze, 2013; Bilda, 2011; McCarthy & Wright, 2004; O'Brien & Toms, 2008). An engagement model for understanding interactions with computer games was developed by Bianchi-Berthouze (2013), which focuses on revealing the relationship

between a player's movements and engagement in playing games. This model differentiates five types of bodily movements (e.g., task control and role playing) and four elements of engagement (e.g., challenge), and the study proposes that the game controller should offer selections for various kinds of bodily movement that could affect how the player engages in interactions with the game. In this regard, the embodied engagement model also suggests that bodily movements play a central role in engagement, especially in the stages of adaptation and exploration, which empirically support the analysis of the audience experience model (4.11) from the case study. In some aspects, this model can be compared to the framework of technology as experience (McCarthy & Wright, 2004), and the experience dimension corresponds to the four threads of experience, while the engagement process resonates with the sense-making model (e.g., evaluation and reflecting, anticipation and anticipating). The creative engagement model (Bilda, 2011) depicts a series of interaction modes and phases in experiencing interactive art, while the engagement model for computer applications (e.g., online shopping) is comprised of four stages (e.g., the start of engagement) (O'Brien & Toms, 2008). Similarly to these two models, the dimension of the interaction process in the embodied engagement model is also based on a temporal form. However, the main differences between them are that the embodied engagement model pays special attention to how bodily engagement influences embodied meaning making, and the four experiential modules are tied to the engagement stages.

7.2.2.4 The unified model of audience experiences

The two models of embodied meaning making and embodied engagement were consolidated into a unified model (Figure 5.17) aimed at understanding audience experiences with ambient media. The process of embodied meaning making is closely tied to audience engagement in the four experience modules. This model incorporates the elements of embodied meaning making (Figure

5.15) into the engagement process, in which the three properties of ambient media are embedded in the whole process. In the stage of Encounter, people usually perceive sensory information (e.g., visual, auditory, and tactile sensations). Visual mapping (e.g., resemblance to a piano, battery) usually occurs in Encounter, which induces direct and initial perceptual impressions elicited by sensory information (e.g., physical shape, color, material). Next, attracted by sensory simulation, people are motivated to explore an ambient media work by performing various bodily actions (e.g., walk, run, stamp on the staircase), and this stage also involves sensory perception (feedback) results from the audience's motor actions, which construct a sensory perception – a motor action loop. Following Exploration, the audience may enter a state of Evaluation (understanding). Immediate embodied metaphorical understanding (e.g., swiping a card across the rope to free people from the constraint of poverty) is triggered by bodily engagements. Audiences also may appraise their experience in the previous stage, which facilitates them reengaging in the exploration to discover more possibilities (e.g., try to make different music effects after firstly round walking on the staircase, swipe card again to gain more interactive experiences). The three engagement stages are a fluent and continuous process involving four experience modules and embodied metaphorical mappings. If the work was able to trigger more reengagement, it could further engage people in meaningful interactions.

7.3 Discussion on designing embodied interactions

The study on designing ambient media yielded two major findings: a set of design strategies and a matrix of embodied schemas and spatial features. Along with the models for understanding audience experiences, the strategies and matrix jointly construct an embodied approach to ambient media design, which have been applied to develop a range of design ideas, and the empirical

evaluation of Reading Door demonstrates the applicability of this approach. Based on the initial discussion in Chapter 6, this section focuses on discussing designing embodied interactions with ambient media regarding the relationship between the properties of ambient media and meaning making, and justifies the approach in regard to related studies.

The findings on ambient media design substantiate the theoretical presumptions about embodiment and the three properties of ambient media. The empirical findings demonstrate that the spatial features in public space (Spatiality) can be employed as the source of affordances for engaging audiences in interactions with ambient media (Engagement), where embodied meaning and an unexpected experience are elicited (Unexpectedness).

Firstly, employing the physical elements of public space in designing ambient media is the application of embodied cognition theory to interaction design, which is manifested in the nature of embodied cognition: cognitive processing is situated in real environments and tied to bodily engagement with the physical world (Wilson, 2002). The coupling of spatial features and bodily actions is consistent with the theory of affordances (Gibson, 1979), as interacting with ambient media is an active process, in which audience may perceive the affordances that “invite” them to perform certain bodily actions. The embodied approach consolidates the theory of affordances from ecological psychology and embodied cognition from cognitive science. In some sense, affordances and embodiment share similar ideas in regard to the complementary relationship between the environment and people, as Heft (1989) claims, “Both Merleau-Ponty and Gibson emphasize that perceiving simultaneously entails an awareness of both the environment and the body.” Moreover, the physical space resembling the features of other objects in visual similarity embodies the idea of visual metaphor (see 2.3.2.3 and 6.4.2),

and extends the idea of image metaphors (Lakoff, 1992), that focus on linguistic expressions, to designing embodied interactions. Visual metaphorical mapping is also a strategy for eliciting unexpectedness, as one object which is out of context is present in the public space.

Secondly, eliciting unexpected responses also plays an important role in embodied interactions with ambient media. Based on the empirical study of the Piano Staircase and the analysis of design ideas (4.3), unexpectedness is closely coupled with engagement with ambient media. When encountering the ambient medium, the visual properties mismatching the physical space in function (e.g., the piano keyboard integrated with the staircase) can attract the audience's attention and increase the perceivability of the affordance for engaging in interaction. The mismatch is embodied within two aspects: the location and the arrangement. An object appears in an unexpected environment (e.g., a book cover appearing on a door), and the arrangement of the object is unconventional (e.g., the book cover is enlarged to door size, the piano keyboard is arranged progressively in a vertical direction). The mismatching, which has been proposed as one of the strategies for eliciting unexpectedness (Table 2), is basically the result of visual metaphor (see metaphorical mapping in Table 2, 3) that alludes to the resemblance in shape between two things, and, thus, is also a means of meaning making in metaphorical mapping. Unexpectedness is also elicited from bodily interaction, and the feedback triggered by the audience's bodily actions may be beyond their expectations. For example, when someone sits on the bench, a light effect appears around him or her (see 4.2 Social Bench); or opening the door triggers a sound like flipping the pages of a book (see 4.2 Reading Door). Although embodied interaction is generally understood as intuitive in use (Hurtienne, 2017) and based on a familiarity with the real world (Dourish, 2001), our emphasis on unexpectedness as a property of ambient media does not contradict the nature of embodied interaction, as ambient media design,

to some extent, is not aimed at serving a practical function (e.g., a product); rather, it is a way enriching people's everyday experiences. We argue that unexpectedness is not only one property of ambient media but also a factor in facilitating engagement and meaningful experiences in interacting with ambient media.

Thirdly, bodily engagement assumes a major role in meaning making in interaction with ambient media, and this argument resonates with previous studies on embodied interaction (Bianchi-Berthouze, 2013; Dourish, 2001; Garde-Perik et al., 2013; Loke & Robertson, 2013). One important aspect of embodied interaction is coupling people's body skills with the interaction of making sense of the world, as "embodiment is the property of our engagement with the world that allows us to make it meaningful...is about the relationship between action and meaning" (Dourish, 2001, p. 126). The embodied approach to movement-based interaction (Loke & Robertson, 2013) pays special attention to the central role of bodily engagement in lived cognition and experience. People's bodily movements have a strong influence on a player's experience in digital games (Bianchi-Berthouze, 2013). Furthermore, the findings from both Empirical Study 1 and evaluation of the Reading Door indicate that meaningful experiences with ambient media rely on the coupling of motor action and sensory feedback. Understandings of meaningful interaction (Garde-Perik et al., 2013; Djajadiningrat et al., 2004; Lu & Cheng, 2013) mainly focus on the functional meaning between the user's action (input) and the system's feedback (output) and how a user easily perceives the affordances of the system. However, this research extends the idea of meaning making through the understandable coupling between form and function by focusing on the embodied metaphorical meaning generated from bodily interactions. In other words, designing embodied interactions with ambient media is especially concerned with the experiential, expressive, and imaginative aspects of audience experiences.

Fourthly, the finding concerning the relationship between spatial qualities and embodied schemas extends the understanding of conceptual metaphors and image schemas in cognitive semantics and HCI. Related studies in HCI have applied the theories of image schemas to investigate task-based interactions with digital interfaces (Hurtienne, 2017) and tangible interactive artifacts (Antle et al., 2011). These have mainly focused upon the correspondence between image schemas and metaphorical meanings rather than the potential schematic meaning generated from interaction with a certain physical space. In the ideation of ambient media design, the matrix of schemas and spatial features, serving as a design instrument, provide direct guidance in conceiving ideas. This considers embodied schemas to be something other than just an analytical lens but also to offer useful design guidance. The findings also extend the studies on embodied metaphor theory such as language comprehension (Gibbs & Wilson, 2002) and product expression (Van Rompay & Ludden, 2015), as the embodied approach of this research considers embodied metaphor as a design source rather than a mere expression of meaning. Many studies, such as those concerning spatial interactions (Hornecker & Buur, 2006) and meaningful places (Ciolfi, 2004), highlight the spatial property in tangible interactions, as the world is perceived in relation to the body as the central reference, and the interactions between people and tangible interfaces are situated in physical space. However, this research focuses on the inherent schematic meanings of physical public space, and how they are extended to embodied metaphors through immediate bodily interactions with ambient media. The matrix (Table 6.1) and the design strategy of coupling bodily actions with the potential schematic meaning of spatial features gives rise to endless possibilities in both design practice and research.

Fifthly, the embodied approach has been differentiated from that of metaphorical design (e.g., Hey et al., 2008; Madsen, 1994). Compared with the concept of metaphor in metaphorical design, embodied metaphor (see 2.3), as a core idea in this research, has two major characteristics. Firstly, the metaphorical mapping of embodied metaphor is activated and formed by the bodily interaction, and the source domain is bodily action (e.g., opening the door), while the target domain is a conceptual meaning (entering a knowledge space). Metaphorical design treats metaphor as a design method, and designers create design forms by means of resembling everyday concrete objects (e.g., the trash bin on a computer desktop denoting recycling deleted files) to increase the usability of a product or a digital interface; or thinking in terms of conceptual similarity (e.g., Bruce is a lion). Secondly, embodied metaphor is structured by an embodied schema that arises from long-term bodily experience, while metaphorical design overlooks the role of embodied schema and bodily experience in meaning making. In this sense, the visual metaphor (similarity in visual appearances) is consistent with the idea of metaphorical design, however, embodied metaphor is a different concept. Van Rompay (2005) has pointed out that embodied metaphors are those grounded in bodily experience while other metaphors rest on a resemblance between two objects.

Overall, the models and strategies from both the interpretive and empirical studies provide systematic guidance for understanding audience experiences and designing meaningful interactions with ambient media.

7.4 Implications for research and design

Based on the discussion of the research findings, this section aims to summarize the theoretical, methodological and design implications that are

expected to inform further research and practice on ambient media and embodied interaction.

7.4.1 Implications for research

According to the classifications of PhD research in design (Poggenpohl & Sato, 2003), this type of research can be classified as methodological research rather than pure theoretical research or empirical research, although the development of the embodied approach is supported by relevant theories and empirical studies. Despite methodological exploration as the major research goal, this research contributes to the existing theoretical body of knowledge in embodied interaction with reference to the following three consolidations: between the bodily action-based approach and the environment-based approach, between embodied metaphor and visual metaphor, and between interpretive analysis and RtD. These combinations of diverse views and approaches are expected to broaden the existing theoretical and methodological visions in the research on embodied interaction, and inspire new possibilities in the design practice of ambient media.

7.4.1.1 The bodily action-based approach and the environment-based approach

This research suggests that consolidating the bodily actions-based approach and the environment-based approach is beneficial to research on understanding and designing experiences in tangible interactions. While embodied cognition emphasizes that cognition is largely shaped by the body's sensory-motor activities, ecological psychology stresses the perceptual relationship that exists between people's behaviors and environments that afford various action possibilities to people. This notion of the complementary relationship between embodiment and environmental affordances has been mentioned by some researchers (e.g., Dreyfus, 1996; Heft, 1989), but it has

not been synthesized as constructive guidance in previous HCI research in regard to embodied meaning making. The consolidation of the two approaches is highlighted in the exploration of the embodied approach that consists of a set of strategies and models. In particular, this research reveals that spatiality as one major property of ambient media can be a starting point for researching audience experiences and embodied interactions. The matrix (Table 6.1) demonstrates that the coupling of bodily actions and affordances could inherently give rise to embodied schematic meaning. Moreover, the four design strategies are also formulated based on the complementary relationship between the body and the environment. Consolidating the bodily action-based and environment-based approaches is a promising attempt to extend the philosophical thought (Dreyfus, 1996; Heft, 1989) to interaction design, which advances the propositions on the focuses on body and context (Hornecker et al., 2017), and embodied design (Van Rompay & Ludden, 2015). This research believes that combining both theoretical concepts will benefit further research on embodied interaction and ambient media.

7.4.1.2 Embodied metaphor and visual metaphor

The second implication of the research is that integrating embodied metaphor and visual metaphor into embodied interactions opens new avenues to study embodied meaning making from both the perspectives of cognitive linguistics and interaction design. The three studies indicated that embodied metaphor and visual metaphor jointly contribute to embodied meaning making through interacting with ambient media in most of the cases. From the perspective of embodied interaction, an embodied metaphor is generated through metaphorical mapping that is tied to and triggered by immediate bodily engagement, while a visual metaphor is formed by a visual similarity between two things (objects or spaces). Based on the findings from the interpretive and empirical studies, the two concepts in the context of embodied interactions can be differentiated from those in cognitive linguistics, since the

research in cognitive science and cognitive linguistics (e.g., Gibbs, 2005; Lakoff & Johnson, 1980) focuses on the embodied grounding of linguistic expressions of embodied metaphors rather than the role of real-time bodily interactions in constructing embodied metaphor, and the linguistic meaning of image metaphors rather than the physical appearance of visual designs. As discussed in 7.3, visual metaphors can elicit unexpected responses through mismatching the design of the resemblance and the context (e.g., a book cover mounted on a door), and further facilitate bodily engagement. The mismatch can attract the people's attention and enhance the perceivability of the affordance for interaction. The integrative approach of combining embodied metaphors and visual metaphors in designing embodied interactions extends the thinking from cognitive linguistics into ambient media design, and improves the research knowledge regarding embodied interaction and audience engagement.

7.4.1.3 Interpretive analysis and research through design

One highlight of the methodology in this research is that it combines interpretive analysis and RtD. The research design exhibits an iterative process integrating the analysis of audience experiences and designing ambient media through three interrelated studies. A range of analytical models are built based on embodied foundations, and by using these models, the three studies involve interpretive analysis in order to explore the way people experience interactive ambient media and to understand the meaning of the experience. Interpretive analysis is embedded in various research phases: the case study on ambient media works, thematic analysis of empirical data, design workshop, design ideation, design evaluation, within which new factors, models, and strategies are derived. A further important implication is that integrating interpretive analysis with RtD makes it possible to transform analytical models into design models or strategies. The case analyses and empirical study on the Piano Staircase produced useful analytical models (e.g.,

the embodied meaning making model) for understanding audience experiences and engagement in interacting with ambient media, which was aimed at answering the first research question. In regard to these analytical models, the third study on designing ambient media produced design strategies and models, and design experiments (ideation, prototyping, testing) were conducted based on the consolidation of RtD and interpretive analysis. In addition, interpretive analysis was also a way to triangulate the findings from the third person empirical study on embodied experience and the first-person design reflections on designing ambient media.

To sum up, this methodological research consolidating various thoughts and perspectives from across disciplines is the first step in exploring embodied interaction design within the context of ambient media, which could facilitate further research on understanding and designing embodied experiences in a broader context.

7.4.2 Implications for design

Based on the discussion regarding understanding audience experiences and designing embodied interactions, this section summarizes three principles for designing embodied interactions with ambient media. These are expected to inform design practice and motivate further explorations of design thinking.

7.4.2.1 Aligning bodily interaction with metaphorical mapping

The first implication for design is that ambient media design needs to consider how bodily interactions can give rise to the metaphorical mapping from the immediate actions (source domain) onto a conceptual meaning (target domain). Specifically, the meaningful congruency between the bodily action (input) and the sensory feedback (output) is the central consideration in designing embodied interactions with ambient media. In most cases, the bodily action plays a major role in constructing the source domain of an

embodied metaphorical mapping (e.g., opening a door), while the feedback (e.g., the sound of book pages flipping) facilitates forming the target domain (e.g., reading a book), especially when the bodily engagement is not very active (e.g., standing). Visual, auditory, haptic, and multimodal feedback can be employed to jointly increase embodied metaphorical mapping. In the idea Hug Pole, the physical warmth and red lighting are activated when a person embraces the heart-shaped cushion. The action of hugging metaphorically results in the psychological warmth, and the heart shape with lighting also facilitates forming the embodied metaphor.

7.4.2.2 Coupling embodied schematic meaning with spatial features

In the early stage of designing ambient media, an effective design method is to generate design ideas through associating the physical affordance of a space with the related embodied schema. The physical affordance of a space is inherently linked to a certain embodied schema. The environmental features in public space offer information to audiences regarding performing certain bodily actions that facilitate the construction of embodied metaphors. This provides constructive guidance for eliciting potential embodied metaphors that are extended from embodied schemas. For example, a trash bin affords the action possibility of throwing physical objects, which may be mapped to another concept structured by a Container schema. As demonstrated in the previous chapter, designers can associate the bodily actions (e.g., tearing a piece of paper towel) solicited by environmental affordances with the embodied schemas (e.g., splitting schema) to create embodied meanings (e.g., cutting trees and destroying forests). The matrix of spatial features and embodied schemas is formulated based on the theoretical consolidation of affordances and embodied schemas, which can be regarded as a design strategy for inspiring ideation in designing ambient media.

7.4.2.3 Creating unexpected responses for enhancing engagement

As discussed in section 7.3, eliciting surprising experiences can facilitate engagement in interacting with ambient media. Three methods for designing unexpectedness (i.e., contrasting input/output (I/O) relations, contrasting physical and virtual contents, and mismatching visual elements and contexts) were applied in the workshop (pilot study) and design ideation. These methods play various roles in different interaction phases, and as a consequence unexpectedness is generated and accompanies embodied meaning making. In encounters, mismatching visual elements and the context is a direct method of attracting the audience's attention and enhancing the perceivability of affordances. Resulting from visual metaphors (the resemblance between two objects or spaces), the mismatch also facilitates metaphorical meaning making. For example, as a visual metaphor, the door designed like a book cover partly contributes to the meaning of book reading. On the other hand, the other two methods (contrasting I/O relations, contrasting physical, and virtual elements) are mainly related to the phase of exploration, and eliciting unexpectedness is interwoven into the process of embodied meaning making.

7.5 Summary

This chapter clarified and synthesized the findings from the main studies, and conducted an in-depth discussion on two aspects of the embodied approach: understanding audience experiences and designing embodied interactions. Based on this discussion, a range of implications was summarized with regard to informing further research and design practice. The three combinations of the diverse perspectives offer new theoretical and methodological insights into the research on embodied interactions, while the three principles can help designers generate new design ideas and create meaningful and engaging experiences with ambient media.

Chapter 8. Conclusion

8.1 Main findings

8.1.1 A research methodology of embodied interaction

8.1.2 Five models of understanding audience experiences

8.1.3 The three principles of ambient media design

8.1.4 Responses to the research questions

8.2 Contributions

8.3 Limitations

8.4 Future research

8.1 Main findings

This research is the first in-depth investigation into embodied interactions with ambient media. The findings of this research provide three aspects of knowledge: a research methodology of embodied interaction, five models of understanding audience experiences, and three principles of ambient media design.

8.1.1 A research methodology of embodied interaction

Building on theories of embodiment and cognitive semantics, an evolutionary exploration of the embodied approach to the analysis and design of ambient media was conducted, which advances a methodology for researching embodied interaction. This methodology consolidates case and empirical studies, deductive and inductive analyses, interpretive study and RtD; and three progressive studies embodied the evolution of the approach. Following the deductive and interpretive analyses, the ten case analyses preliminarily examined the theoretical assumptions and provided an overall understanding of embodied interactions with ambient media. Furthermore, the empirical study advanced the findings of the case study by combining prototyping,

experiments, and thematic analysis. The coding scheme (Table 5.4) was generated from both the deductive and inductive analyses and can be employed as a useful reference for qualitative research on embodied interaction. Following RtD principles, the study on designing ambient media integrated design methods (ideation, sketching, and prototyping) and research methods (interpretive analysis of design ideas, experiments using experience tests, and thematic analysis). Design experiments also applied and advanced the analytical models and methods generated from the case study and empirical study, which demonstrated that the design experiments (design workshop and designerly ideation) can be a way to validate theoretical and interpretive analyses. As illustrated in Figure 3.2, the research methodology not only embodies the process of exploration concerning the knowledge body of ambient media design but also reflects the epistemology in various research phases. The research design offers researchers useful guidance on interaction design research, and the relevant methods or models can be adopted from it according to the questions and goals of researchers.

8.1.2 Five models of understanding audience experiences

The case study and empirical study developed a range of ways to understand audience experiences in interaction with ambient media. First, the analytical model (Table 4.1) integrates key components of the theoretical framework, and it can be used for descriptive and interpretive analyses of audience experiences and embodied interactions. The model of audience experiences (Figure 4.11) can help to gain an initial understanding of audience experiences and embodied interactions with ambient media. On the other hand, the empirical study produced two major findings: the model of embodied meaning making (Figure 5.15) and the model of embodied engagement (Figure 5.16). The former focuses on helping researchers understand how bodily actions and embodied schemas jointly influence meaning making and cognitive experience, while the embodied engagement model illustrates how

an audience is engaged in interactions with ambient media in experiential and temporal dimensions. The two models were consolidated as a unified model (Figure 5.17) that reflects the mechanism between audience engagement and meaning making in interactions with ambient media. In sum, the five models provide useful tools for analyzing audience experiences, embodied engagement, and meaning making in interpreting existing cases or developing ambient media works.

8.1.3 The three principles of ambient media design

The three principles (6.4.4.4), as the major findings of the study on designing ambient media, were summarized based on the design workshop, design ideation, interpretive analysis, and empirical evaluation. They can be used as guidelines in designing embodied experiences with ambient media. More specifically, the principles can be followed by designers according to the four strategies (6.2.1) and the matrix (Table 6.1). The first principle “Aligning bodily interaction with metaphorical mapping” corresponds with the strategy “Coupling audience’s bodily actions with sensory feedback in regard to metaphorical meaning making.” Secondly, the principle “Linking embodied schematic structures with spatial features” is embodied in “Considering the congruency between embodied schema and bodily actions” and the matrix of embodied schemas and spatial features. Thirdly, “Designing action-perception (Input/Output) relations for eliciting unexpectedness” is consistent with “Eliciting unexpected experience by designing input/output relations.” These principles and strategies not only provide practical and useful guidelines in ambient media design but also form a reference for designing meaningful experiences in other contexts.

8.1.4 Responses to the research questions

As discussed in the previous chapter, the two main research questions are answered through three progressive studies. Guided by two main research

questions: 1) “How can audience experiences with ambient media be understood from an embodied cognition perspective?” and 2) “How can a design approach be developed to support embodied interactions with ambient media?”, the research is conducted to understand audience experiences and design embodied interactions with ambient media. Accordingly, the findings from the three studies provide concrete answers to the research questions.

For the first research question, the five models (see Section 8.1.2), as main findings from the case study and the empirical study, provide a range of methods and perspectives to analyze and investigate audience experiences with ambient media. For example, the model of audience experiences (Figure 4.11) can help researchers get initial understandings on audience experiences and embodied interactions with ambient media. The model of embodied meaning making (Figure 5.15) focuses on understanding how bodily actions and embodied schemas influence meaning making and cognitive experiences. As a direct response to the first research question, the findings from the case study and the empirical study construct an analytical methodology for the research on understanding audience experiences with ambient media.

On the other hand, the study on designing ambient media focuses on answering the second research question. The methodology of research through design is employed to develop the design approach. Through ideating, sketching, prototyping, experimenting, and analyzing, the third study develops an embodied design approach to designing ambient media. The major findings include a set of design strategies (6.2.1), the matrix of embodied schemas and spatial features (Table 6.1), and three design principles (6.4.4.4), which jointly form the design approach. The study of designing ambient media also applies the analytical models from the

empirical study as valuable methods for evaluating audience experiences with designed works.

More specifically, the sub-questions are answered in each research phase: Chapter 2 reviews relevant literature to establish a theoretical framework, which responds to the first sub-question “What theoretical framework can be established to support understanding audience experiences and exploring an embodied approach?”

The case analyses and the empirical study on Piano Staircase aim at understanding audience experiences and embodied interactions with ambient media, which jointly answer the second sub-question “How can embodied interaction with ambient media be understood?”

The coding scheme (Table 5.4) formulated in the empirical study identifies a range of main factors of audience experiences with ambient media, which responds to the third sub-question “What major factors can be identified in people’s experiences with ambient media?”

The three models (i.e., Figure 5.15, Figure 5.16, Figure 5.17) developed in the empirical study reflect the relationship between bodily actions and meaningful experiences, which answer the fourth sub-question “Does bodily engagement facilitate meaningful experiences with ambient media and if yes, how?”

The design strategies (see 6.2.1) derived from the empirical study answer the fifth sub-question “What design strategies can be derived to support ambient media design?”

The study on designing ambient media develops an embodied design approach and conducts audience experience tests and evaluations, which responds to the sixth sub-question “How does an embodied design approach guide ambient media design and how can it be evaluated?”

Chapter 7 makes in-depth reflections and discussions, and the implications for research and design are presented to answer the last sub-question “What implications of this research can inform future endeavors in the field?”

8.2 Contributions

In regard to the major findings, the contributions of this research are contained within three aspects: interaction design research, design practice in related industries, and design education.

This methodological research represents the first exploration of investigating embodied interactions with ambient media. The consolidation of diverse viewpoints and approaches broadens the existing theoretical and methodological visions in the research on embodied interaction. The integration of the bodily actions-based approach and the environment-based approach benefits the research on HCI and meaningful interactions in the context of public space. The consolidation of embodied metaphor and visual metaphor in designing embodied interactions extends the thinking from cognitive linguistics into ambient media design, and progresses the research knowledge concerning embodied interactions and audience engagement. The interwoven use of interpretive analysis and RtD provides an applicable reference and methodological guide for other related studies.

Practitioners in interaction design and ambient media design can apply the embodied approach including a set of the analytical models and design

guidelines in design practice, and these tools and insights may inspire new possibilities in the design practice of ambient media. With regard to specific design applications, the embodied approach can be applied to ambient advertising (branding) design, interactive space design, and museum experience design. Using the five models, designers can evaluate and analyze audience experiences, embodied engagement, and meaning making in developing interactive systems. Interaction designers can also develop new designs for meaningful interaction by applying the strategies and the matrix of embodied schemas and spatial features.

In design education, the methodology and the embodied approach provide rich content with regard to related subjects. Teachers can adopt the interpretive analysis on ambient media cases and empirical data from the experience tests as concrete examples for teaching interaction design. The design strategies and models can be employed as design thinking tools not only by students in interaction design and digital media programs, but also by those in environmental design or advertising design programs. In addition, the research design consisting of the combination of a case analysis, empirical study, and design experiments offers a useful model for postgraduate education.

8.3 Limitations

The empirical study on the Piano Staircase accomplished an in-depth investigation of an audience's embodied interactions with an interactive prototype, which not only substantiated the interpretive analysis in the case study but also gave rise to the models for understanding embodied meaning making and engagement. However, this study primarily provided empirical evidence for the analysis of one case. The underlying mechanism of bodily actions and embodied meaning making may be further enriched and

advanced if more cases are rebuilt and more experience tests are conducted on them. Moreover, as most of the participants were recruited from the university campus, the properties of spatiality and embodied interactions with ambient media may be better understood if the prototype can be installed in a venue in which people from more diverse backgrounds can be involved in the study.

Although the matrix of embodied schemas and spatial features indicates the underlying relationship between environmental affordances and embodied schematic meanings, only partial schemas and spatial features were included, and the number of cases used as examples was relatively small. Expanding the two dimensions and completing more ambient media cases may make the matrix more comprehensive and applicable. Furthermore, the matrix only reflects the mapping between a schema and a spatial feature in one case. However, the case analyses and empirical study indicate that the interaction with a particular ambient media work may involve more than one schema (e.g., Moments of Warmth related to the Container and Part-Whole schemas), and further investigation of the mechanism of multi-schematic meaning making is needed. The matrix as a tool for design thinking has been applied by the researcher to formulate a range of design ideas, but novice designers may have some difficulties in choosing embodied schemas in order to deliver specific meanings (e.g., a design topic) in some public environments (e.g., an urban square). Further study is needed to validate the approach in terms of its accessibility to other designers.

In addition, as the implications of the study previously stated (7.4.1), sensory feedback plays an essential role in embodied meaning making and eliciting unexpectedness, but the main sensory feedback was auditory in the two empirical studies (i.e., the Piano Staircase and Reading Door). Multimodal

interactions with ambient media and their relationship to embodied meaning are less explored in the present research.

8.4 Future research

As the first study conducted upon embodied interactions with ambient media, various possibilities exist for further research with regard to the scope and depth of the research.

There are four aspects worthy of further study. Deeming emotional responses as an important component in audience experiences, a future study will explore the mechanism that exists between emotional experiences and embodied interactions in interacting with ambient media, as the three studies in the present research were mainly focused on investigating how bodily interactions influence cognitive and meaningful experiences.

As mentioned in the previous section, the conducted studies indicated that the meaning making in interactions with some ambient media may involve more than one schema (e.g., Interaction with Lighting Corridor (Figure 6.12) involving Path schema and Orientation schema), and future research will further investigate embodied meaning making with regard to the multi-schema involved in the metaphorical mapping. More work will also be completed to expand the two dimensions of the matrix of embodied schemas and spatial features and complement the corresponding ambient media cases as applicable references for design practice.

In addition to the auditory sense, future research will explore the role of other modalities (e.g., visual, tactile feedbacks) in embodied meaning making. Using the Reading Door as an example, this would involve the door being made of flexible materials, or displaying lighting effects, which create opportunities for

the audience to perceive tactile or visual feedback. The embodied meaning making in multimodal interactions with ambient media will be further investigated.

With regard to the depth of the research, future studies will conduct related design workshops and experiments to apply and advance the embodied approach. More specific design methods and guidelines will be developed based on further explorations. The three studies were conducted without regard to business contexts and specific applications. Instead, this research was focused on the relationships between three properties of ambient media and embodied meaning. However, with regard to design applications, the embodied approach can be applied to designing ambient advertising (branding), interactive architecture, and museum experiences. The researcher will be more engaged in advancing the embodied approach with more concern for these design contexts.

In order to improve and strengthen the embodied approach, future research will involve other methods than existing methodology to triangulate and validate design assumptions. For example, A/B testing could be used to examine how the four design strategies guide design, and three conditions (Table 6.2) can be tested based on one ambient media work (e.g., one, two, and three strategies involved for triggering unexpectedness). In addition, physiological sensors also can be applied in empirical studies on ambient media works, and biofeedback data can be analyzed to understand participants' bodily experience, which can further triangulate the results of the analysis on verbal reports.

In summary, this research provides an embodied approach to understanding audience experiences and designing ambient media through interpretive and empirical studies, which construct a basis for studies in related fields. With

regard to scope and depth, this implies that a range of possibilities exist for further investigations.

Appendix 1.



INFORMATION SHEET

A STUDY ON AUDIENCE EXPERIENCE WITH AMBIENT MEDIA

You are invited to participate in a study conducted by Mr. TAN Liang, who is a PhD candidate of the School of Design in The Hong Kong Polytechnic University. The project has been approved by the Human Subjects Ethics Sub-committee (HSESC) of The Hong Kong Polytechnic University (HSESC Reference Number: 20160929001).

The aim of this study is to investigate the audience experience with a physical space. Firstly, you will be invited to experience an installation in a public space. The process of experiencing will be videotaped as document for analysis. This session will not have time limitation, but the proposed duration will be about 2-5 minutes. Then, you will be involved in a face-to-face interview to talk about your feeling and thinking. Finally, a questionnaire will be completed for evaluating some factors. The whole experiment is expected to help the researcher to understand audience's bodily and cognitive experience with the installation in the public space.

The testing should not result in any undue discomfort, but you will be observed, photographed, and videotaped. All information related to you will remain confidential, and will be identifiable by codes only known to the researcher.

You have every right to withdrawn from the study before or during the observation without penalty of any kind. The whole investigation will take about one hours. To be compensated for your participation in this study, you will be asked to complete and sign a Receipt of Compensation Form after the investigation.

If you would like to get more information about this study, please contact Mr. TAN Liang on tel. no. +852 2766 5466; email address: liang.tan@

If you have any complaints about the conduct of this research study, please do not hesitate to contact Ms Kath Lui, Secretary of the Human Subjects Ethics Sub-Committee of The Hong Kong Polytechnic University in writing (c/o Research Office of the University) stating clearly the responsible person and department of this study.

Thank you for your interest in participating in this study.

Mr. TAN Liang
Principal Investigator/Chief Investigator

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CONSENT TO PARTICIPATE IN RESEARCH

A STUDY ON AUDIENCE EXPERIENCE WITH AMBIENT MEDIA

I _____ hereby consent to participate in the captioned research conducted by Mr. TAN Liang.

I understand that information obtained from this research may be used in future research and published. However, my right to privacy will be retained, i.e. my personal details will not be revealed.

The procedure as set out in the attached information sheet has been fully explained. I understand the benefit and risks involved. My participation in the project is voluntary.

I acknowledge that I have the right to question any part of the procedure and can withdraw at any time without penalty of any kind.

Name of participant _____

Signature of participant _____

Name of Parent or Guardian (if applicable) _____

Signature of Parent or Guardian (if applicable) _____

Name of researcher _____

Signature of researcher _____

Date _____

參與研究同意書

A STUDY ON AUDIENCE EXPERIENCE WITH AMBIENT MEDIA

本人_____同意參與由譚亮先生開展的上述研究。

本人知悉此研究所得的資料可能被用作日後的研究及發表，但本人的私隱權利將得以保留，即本人的個人資料不會被公開。

研究人員已向本人清楚解釋列在所附資料卡上的研究程序，本人明瞭當中涉及的利益及風險；本人自願參與研究項目。

本人知悉本人有權就程序的任何部分提出疑問，並有權隨時退出而不受任何懲處。

參與者姓名 _____
參與者簽署 _____
家長或監護人(如適用) 姓名 _____
家長或監護人(如適用) 簽署 _____
研究人員姓名 _____
研究人員簽署 _____
日期 _____

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