

## ENRICHING THE AESTHETICS OF MOBILE MUSIC PLAYER INTERACTIONS THROUGH THE USE OF PERSONAL CLOTHING AND ACCESSORIES AS INTERFACES (1)

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1. This article is based on the research in the Master's thesis entitled as "Potentials of Embodied Interactive Technologies to Enhance Mobile Listening Experience in Public Environment" (Şen, 2014) and submitted to Department of Industrial Design, Middle East Technical University. An initial version of this paper (Şen and Şener, 2014) was presented at the 20th International Conference on Engineering Design (ICED 2015) held in Milan, Italy, 27-30 July 2015. It is substantially updated for the article with specific focus on the methods and results of the generative session where personal clothing and accessories were reinterpreted as a means of mobile music player interfaces.

### INTRODUCTION

The use of digital technologies has expanded from computers and smart phones to a wider range of products including furniture, clothing and personal accessories. The miniaturization of electronics, as well as advancements in material technologies such as conductive fabrics and shape memory alloys made the transfer of the programmable and expressive features to such daily physical items easier. Designers of the digital products or systems have also started to make use of the intimacy that we have with daily physical items such as clothing and wearable accessories. This is observable in health trackers in the form of mundane bracelets such as Leaf Urban by Bellabeat (2016) or regular wrist watches as in the example of Helvetica 1 Smart by Mondaine (2016). Such seamless integration of digital technologies to our body and physical activities can also be illustrated by Levi's Commuter™ Jacquard Jacket developed by Google. It is a smart denim jacket with a conductive yarn and a detachable tag enabling urban cyclists to connect and control some mobile services (music, maps, phone calls) with swipes and taps on the interactive jacket cuff (Levi Strauss & Co., 2016). Other examples such as organic photonic skin (Yokota et al., 2016) or the skin-worn sensor -iSkin- (Weigel et al., 2015) turn random body parts into the means of input/output. These examples make us question the approaches followed in the combination of digital technologies and physical items. The role of computation in expansion of the expressive and smart characteristics of physical products is already acknowledged in the literature (Vallgård and Sokoler, 2010; Hallnäs, 2011; Wiberg, 2015). Vallgård and Sokoler (2010) list these characteristics (that they call properties of computational composites) as temporality, reversibility, accumulation, computed causality, and connectability. Nevertheless, this paper tackles the question of "How does the physicality inspire or enrich our interactions with digital systems?" It aims to identify the role of physicality in aesthetics of user and digital product interactions within the scope of mobile music player (any form of mobile listening)

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interactions. First, it touches upon the relationship between the concepts of aesthetics of interaction and embodied interaction. Then, considering the mobile listening experience, it analyses this relationship by presenting a generative design session where participants were asked to utilize personal clothing, accessories and gestures as means of mobile music player controls. The scope of the controls explored in this research covers the main listening controls that are frequently used by the users on the go; including pause/play; volume up/down and skip back/forward (advancing songs). The interactions that require data input (entering an album name) and the feedbacks were out of the focus of the study.

## LITERATURE REVIEW

The term aesthetics of interaction emerged from the need to explain the appreciation of our sensory experience of the products, which goes beyond the appreciation of the visual appearance. In other words, it is used to define/design products which are not only pleasant to look at, but also pleasant to use (Djajadiningrat et al., 2004). Main arguments in aesthetics of interaction literature (Petersen et al., 2004; Locher et al., 2010; Djajadiningrat et al., 2004; Hummels and Overbeeke, 2010) have common points with Peterson et al.'s (2004) reflections on pragmatist aesthetics. First, they claim that it is not possible to talk about an autonomous aesthetics of products since we cannot judge them as pleasant to use without interacting with them. Second, they underline that appreciation of our physical interactions also involves an intellectual process, a meaning creation/reflection on action (Hummels and Overbeeke, 2010). Finally, they criticize the understanding of aesthetics as an added value and argue that we should approach aesthetics as a significant element of understanding an interactive system. All these arguments highlight the role of physical encounter in creation of meaning and aesthetics of interaction and how aesthetic experience emerges from the context and use. Hummels and Overbeeke (2010) make a similar claim while they discuss the foundations of the concept of aesthetics of interaction. They assert that "our bodies are mechanical: all interaction is essentially mechanical, or tangible. We have few other ways to interact with the world. Therefore, embodiment is essential" (Hummels and Overbeeke, 2010, 2). Embodiment or embodied interaction defines the way we experience the world through directly acting in it by making use of the physical and social affordances it provides us (Dourish, 2004). While presenting the concept of embodied interaction, Dourish (2004) puts a special emphasis on understanding the action possibilities within the context through field studies. This helps designers creating a particular form of computing that fits best to a specific context, also observing how daily objects can provide new dimensions to the interaction via their direct embodiment in our practices (Dourish, 2004). For example, the most used functions of a remote can be recognised just by looking at the changes on the button surfaces.

The introduction of new types of user interfaces such as tangible user interfaces-TUI (using physical objects as representation/control of the digital data) (Ullmer and Ishii, 2001); organic user interfaces-OUI (shape-changing input/output) (Holman and Vertegaal, 2008) and gestural user interfaces (using body as input) can be regarded as steps to embodied interaction. In other words, there is a material turn (Wiberg, 2015) or a transition from data-centric to action-centric view which sees physical objects and bodily movements as resources of action (Fernaesus et al., 2008).

User interfaces integrating embodied interaction present advantages and disadvantages. Regarding the advantages of TUI, Shaer and Hornecker (2010) and Dourish (2004) claim that user's familiarity with the physical world contributes to easier interpretation of digital systems through tangible thinking. It can also be argued that the variety of physical alterations in size, weight, colour or position of the objects multiplies the physical affordances, hence multiplies the ways we interact with digital data (Shaer and Hornecker, 2010). The disadvantages of TUI are discussed as rigidity (not being able to modify the formal qualities of objects according to the dynamics of interaction) and scalability (physical objects demanding the same place even if they are not in use) (Shaer and Hornecker, 2010). OUI share the above-mentioned advantages of TUI and bring solutions to the issues of rigidity and scalability by extending the physical representations and manipulations of the digital data through flexibility of the interface. These flexible representations and manipulations include changes in objects' orientation, form, volume, texture, viscosity, spatiality as well as the alterations through adding/subtracting and permeability (Rasmussen et al., 2012). Gestural controls are advantageous regarding the elimination of the physical means of interaction (Saffer, 2008) and the problems they bring such as scalability. Nevertheless, they do not offer physical affordances to guide the users, they require a separate means of (visual) feedforward and feedback (Norman and Nielsen, 2010). Social acceptability is also discussed as a legitimate concern for the use of such unprecedented forms of interaction (especially gestures) in the public context both from the users' (Rico and Brewster, 2010) and observers' (Profita et al., 2013) point of view. These studies present the national setting (cultural conventions), type of location, audience and the novelty of the technology among the factors affecting the social acceptability-willingness to use such interfaces. In addition, all these interfaces may pose a risk of user fatigue due to the reliance on the physical manipulations and the body movements (Shaer and Hornecker, 2010; Saffer, 2008).

### **THE CASE: EXPERIENCE OF MOBILE LISTENING IN PUBLIC ENVIRONMENT**

The history of mobile listening draws back to the introduction of Sony Walkman, which is an upgraded music player providing privacy and portability. Since then, music players became the products that accompany our daily journeys in public environment. Nowadays, playing music is almost a default function embedded in portable consumer electronics like smart phones, smart watches, and headphones.

As mobile listening is a private activity performed in shared environments and on-the-go, the experience is a challenging one, considering the distracting audio and visual stimuli surrounding the listener and the synchronized activities like using public transportation. This challenge increases with the user interfaces (graphical user interfaces, touch gesture or button-based controls) which are dependent on visual modality of users.

These challenges encourage us to consider the following design opportunities: Is it possible to expand the area of interaction and/or the ways we interact with music players (any form of mobile listening)? Can we utilize the way we interact with our clothing and accessories (most of which already exist in the context and accompany us in our public journeys) or the bodily movements to rethink the way we interact with music players?

Based on the questions presented above, this paper refers to a specific user study “Dreaming about the Journey” conducted as part of a fieldwork of a broader research exploring potentials of embodied interaction technologies to enhance mobile listening experience (Şen, 2014). The fieldwork consisted of three progressive studies:

- Study 1: Telling about the Journey
- Study 2: Living in the Journey
- Study 3: Dreaming about the Journey.

The term journey was used with reference to the daily urban travelling activity accompanied by music. The studies shared a parallel structure and motivation with the research framework Say-Do-Make of Sanders and Dandavate (1999). The methods used in each of the three studies were appropriated for the current research context. The number and the composition of the participants differed in Study 1 to 3 so that Say-Do-Make can be put into practice more effectively.

Among the three studies, Study 3 constitutes the main source for this paper. However, Study 1 and 2 will be presented to demonstrate how the research examined the experience of mobile listening together with the challenges and potentials in physical context.

Study 1 was conducted as a user journey mapping session to enable participants to reflect on their previous (mobile listening) experiences as in Say methods. It appropriated customer journey mapping which is defined by Abbing (2010) as creation of a graphical representation of the steps and stages a customer goes through whilst experiencing a product or service. The participants were internationally mixed group of five mobile listeners. They were asked to reflect on their previous mobile listening experiences by filling in a pre-prepared chart, which consisted of various stages of their journey of mobile listening (preparation, travelling with music, ending the journey) in columns and particular categories to evaluate each stage in rows. Having experienced mobile listening in different public contexts, the participants were able to report a variety of the challenges. Being in a small group of people gave participants enough time to express themselves. The results of Study 1 revealed the participants’ concerns about the contextual factors, such as mobility of users (if the product can be controlled on-the-go) or presence of other people (concerns for safety of the device in crowded places).

Study 2 was conducted with 16 participants/mobile listeners different to Study 1. It enabled the participants to experience a literal journey in the city with music and to reflect on their current (mobile listening) experiences as Do methods aim to achieve. Each participant was asked to choose one mobile listening device from four possible devices (each with varying interfaces) made available to them. Then, they were asked to use the selected mobile listening device in a journey route within the city, while completing several pre-defined public activities at the same time. They were given a printed map explaining the steps of this forty-five-minutes-journey accompanied by music. These steps can be exemplified with using a public transportation or buying a cake from a street buffet. At the destination of their journey, a post-interview was conducted to collect data when the participants’ experiences were fresh. The content analysis of the interview results helped us to understand users’ concerns about i) user-others interactions (proximity, listener’s appearance, audio-visual detachment from the public, alternative ways to communicate,

privacy). ii) product-product interactions (portability decisions affected by product's safety, product's accessibility, listener's appearance, prevention of accidental controls, and orientation of the product controls), and iii) user-product interactions (such as feel and hear of controls: need of audio feedbacks and textural cues for head-mounted MP3 players). Further list of concerns and the comprehensive analysis is presented by Şen and Şener (2014).

To sum up, the outcomes of Study 1 and Study 2 provided the backbone for the execution of Study 3, which was conducted with four participants who also participated in Study 2: *Living in the Journey*. Having recently reflected on their challenging journey with music in public environment, it was easier for the participants to imagine themselves within the context and reinterpret personal clothing, accessories and gestures as means of controlling mobile listening media in the generative session. Furthermore, the identification of users' concerns regarding user-others, user-product and product-product interactions in first two studies guided the analysis of Study 3, especially in terms of the discussion on practicalities of the proposed ways of interactions. First two studies were more concerned about the practical matters/challenges within the context that we need to keep in mind while designing mobile listening interaction. On the other hand, through the generative session "Dreaming about the Journey" we will now deeply elaborate on the above-stated question of "How does physicality enrich the way we interact with digital systems?" and present new projections for interaction aesthetics of music players.

## **DREAMING ABOUT THE JOURNEY: THE METHODOLOGY**

### **The Reinterpretation of Generative Session and Embodied Imagination as a Make Method**

This section will present the methodological details of Study 3: *Dreaming about the Journey* and explain how generative session and embodied imagination were reinterpreted to find out the way personal clothing and accessories inspire the way we interact with music players.

If we refer to the qualitative research framework *Say-Do-Make* (Sanders and Dandavate, 1999), the current study appropriated make methods which aim to reveal users' tacit knowledge about a specific experience by letting them to express themselves by making things in generative sessions. If the generative session is part of a product design research, the participants are usually provided with physical toolkits (2D-3D geometrical objects, stickers etc.) to build their dream products. This study differed from the above-mentioned generative session practices in particular aspects: Since the aim of the research was to explore mobile listening interactions and to reveal the relationship between embodiment/physicality and aesthetics of interaction, instead of building things we asked participants to perform interactions. The toolkit used in these performances involved mobile listening devices and daily objects that we carry and wear while travelling in public environment with music. The participants were also asked to come to the venue with their outdoor clothing like jackets, raincoats and accessories. This increased the variety of the physical objects to be used as resources of action. Using daily wearable/portable items also enabled participants to act naturally. **Figure 1** shows the toolkit involving mobile listening devices (headphones, earphones, and MP3 players),



**Figure 1.** A view from the venue and the daily objects provided in the session

clothing (raincoats, scarves, hats, gloves), and accessories (sunglasses, wrist watches, necklaces, bracelets, rings, key chains, bags, purses, umbrellas).

Embodied imagination (Hansen and Kozel, 2007) is another specific method that we would like to refer in relation to Study 3: Dreaming about the Journey. This method uses low fidelity models (introduced as if they have certain capabilities like communicating body data) and physical notebooks for participants to record how they imagined using that model in specific use conditions. Study 3 had some common points with embodied imagination method: It also made use of imagination and performance to reinterpret a physical toolkit, in the context of mobile listening. However, in our research, the participants were allowed to experience mobile listening in the real context in advance (Study 2: Living in the Journey), and then to imagine a wide range of daily wearable/portable objects as means for music player controls during the session (Study 3: Dreaming about the Journey). This empowered the researcher to observe and record the performances in person, which is not possible with embodied imagination techniques mentioned above.

### Participant Sampling

The number of participants was limited to four to enable the researcher to concentrate on each participant's performance better. The criteria for participation included attendance in Study 2 as its participants had been selected from people with regular mobile listening activity. The study was advertised through e-mail and the volunteers were selected in a way that the four participants of the generative session involved at least one male and one female. This was to increase the variety of the accessories or clothing to be used as toolkit.

### Venue

The study was carried out in a classroom with wide enough space for table discussion and for the participants to act out the bodily interactions (**Figure 1**).

### Study Protocol

The session was started with a warm-up presentation that overviewed the activities carried out in Study 2: Living in the Journey. Photographs from the journey route and highlights from the interviews were shared with the participants to get them more into the topic and the context. The generative session then continued with the following stages:

1. Overview of non-instrumental interactions and alternative ways of controlling available devices: It was questioned whether alternative tangible controls could be offered for available mobile listening devices. In this regard, non-instrumental

product interactions, such as “playing with or caressing the product” (Desmet and Hekkert, 2007, 58) were expected to be inspirational.

2. Utilization of daily objects: The participants were encouraged to dream about making use of the tangible properties of daily objects to control music. The products were selected among their personal clothing and accessories that already accompany users while they are listening on-the-go.
3. Utilization of bodily gestures: The participants were expected to ‘perform’ listening related controls through bodily movements/gestures.
4. Controls beyond the limits of technology: The participants were encouraged to think beyond the limits of the existing technologies and come up with controls that exploit as various sensory modalities as possible.

### Limitations of the Study

- The scope of the controls to be explored by the participants was kept limited to the main listening controls including pause/play; volume up/down and skip back/forward (advancing songs). However, the participants were also welcomed to explore the alternatives for other controls such as shuffle and playlist selection in case they feel that an object irresistibly affords (Overbeeke and Wensveen, 2003) to perform a specific control.
- The session did not focus on the interactions that require data input (entering an album name). This would have required an exploration and discussion on using other means of input (graphical user interface, voice command) in addition to the embodied interaction types explored in the paper.

## RESULTS AND ANALYSIS

The generative session was recorded with a video camera, the performed responses of the participants were also photographed. The video recordings helped to complete the missing visuals with screenshots and to note down the examples which were not performed but only spoken.

The initial analysis included the categorization of the photographs within emerging themes. The participants’ justifications of the controls were also added under the related themes. The themes were formed by the way that participants interacted with or interpreted available mobile listening devices; the way they utilized daily objects used in listening on-the-go or in accompanying activities; and, the way they defined particular bodily movements/gestures as controls. With further classification of the responses according to different types of controls (such as play/pause) the analysis process was completed.

Results of the Study 3: Dreaming about the Journey will be presented under four categories derived from the four different stages of the generative session: i) non-instrumental interactions and alternative ways of controlling available devices; ii) utilization of personal clothing and accessories; iii) utilization of bodily movements/gestures; and, iv) exploration of different sensorial interactions. The four categories and related sub-categories that present the approaches followed in use of physicality for music player


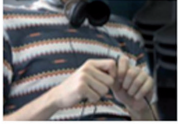







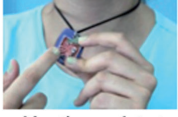
| The approaches followed in use of physicality for music player interactions  | Sub-categories  | Example   |
|--|---|---|
| <br>non-instrumental interactions and alternative ways of controlling available devices | controls inspired from non-instrumental interactions                                    | <br>Bending cables to volume down                  |
|  | controls performed beyond the designed interface of available mobile listening products | <br>Reversing the player to pause                  |
| <br>utilization of personal clothing & accessories                                      | depiction of potential areas to attach controls   | <br>Controls on the backpack handle                |
|  | utilization of the objects already involved in accompanying activities                  | <br>Pausing the song when the wallet is open       |
|  | physical manipulations of the daily objects as controls                                 | <br>Pulling the right end of scarf to skip forward |
| <br>utilization of bodily movements/gestures  | Controls performed with gestures  | <br>Clapping the hands to play/pause             |
| exploration of different sensorial interactions  | taste, tactility, sound   | <br>Touching the rough texture to shuffle        |

Table 1. The approaches followed in use of physicality for music player interactions

interactions can be seen in **Table 1** with exemplary images from the participants' responses.

### Non-Instrumental Interactions and Alternative Ways of Controlling Available Devices

#### Controls Inspired from Non-instrumental Interactions

Attribution of a volume down function to bending cables by a participant who made use of deformability of the cables and constructed an analogy between the sound coming through the cables and water coming from a pipe can be given as an example (**Figure 2**).

#### Controls Performed Beyond the Designed Interface of Available Mobile Listening Products

By referring to Study 2, all participants demonstrated particular actions that they used as controls instead of the controls offered by the interfaces of available products. This revealed the hidden functions behind the actions performed with mobile listening devices. They can be exemplified with the





**Figure 2.** Decreasing volume by bending the cable

situations where users take off headphones as a reflex to give a pause to the listening activity when they have to become involved in a conversation or want to direct their attention to something else than music. In the generative session, there were also some alternative controls provided through attribution of functions to the alternative physical manipulations of available mobile listening devices. To illustrate, turning over to reveal the back of the music player was defined as a device-based gesture to pause the music (**Figure 3**). In another example, a participant offered changing the playlist by changing the bodily location of where the music player is carried (**Figure 3**). As mentioned in Study 2, eyes-free button-based controls could pose problems while selecting a playlist or song, because they require constant advancing of the playlists/songs. So, what the participant did in this session can be regarded as enhancing eyes-free controls by creating a physical layout for playlists on the clothing/wearable.

### Utilization of Personal Clothing and Accessories

#### Depiction of Potential Areas to Attach Controls

Some participants made use of the daily objects solely to attach the existing controls rather than redefining the way of performing these controls by physically manipulating the objects as shown in **Figure 4**. These decisions were mainly driven by the accessibility of the controls.

**Figure 3.** Pausing the song by reversing the music player, changing the place of the device to change the playlist





**Figure 4.** Depiction of potential areas to attach the main controls

### Utilization of the Objects Already Involved in Accompanying Public Activities

The examples grouped under this category help us to question whether the way users interact with the objects used in/for accompanying public activities like shopping could directly transform into the controls of mobile listening devices. A participant stated that it would have been useful if the song was paused automatically when the wallet was opened to concentrate on the purchasing activity (**Figure 5**).

### Physical Manipulations of Daily Objects as Controls

Participants reinterpreted affordances and material properties of daily objects to propose new types of controls for listening to music.

Examples for pause/play (**Figure 6**) include a tap on the flat necklace, a tap on the skirt, pulling the stripe of an umbrella, stretching the elastic bracelet and leaving it back, and turning the elastic bracelets inwards.

Examples for skip back/forward (**Figure 7**) include pulling the fasteners on the right or left side, pulling right or left end of the scarf down, tilting the water bottle towards left and right, turning the hat, turning the brooch in clockwise or counterclockwise.

Examples for volume adjustment (**Figure 8**) included sliding the zip, swiping fingers through the edge of the skirt's pocket; by turning the umbrella clockwise or counterclockwise, and swiping the circular frame of



**Figure 5.** Pausing the song when the wallet is open



**Figure 6.** Pausing and playing the song



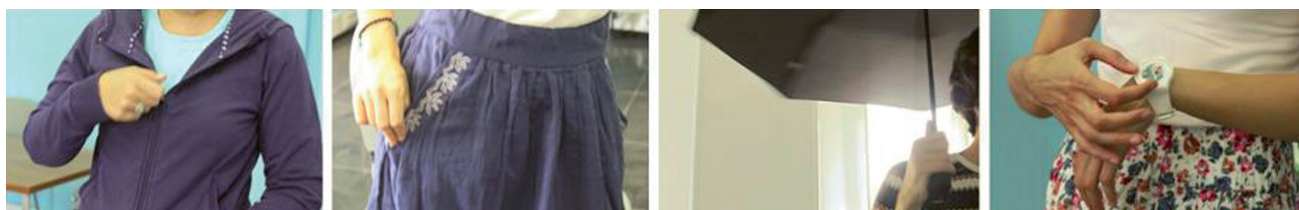
**Figure 7.** Skipping to the next or previous song through physical manipulations of clothing and accessories

the watch. **Figure 9** shows other controls like shuffle functions performed through physical manipulations of clothing and accessories.

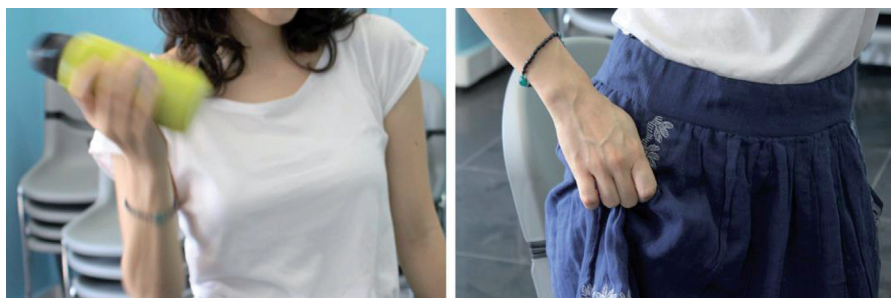
### Utilization of Bodily Movements/Gestures

This category presents the listening-related controls performed with bodily movements. Whilst using some gestures participants also utilized daily objects. However, it is essential to mention that the key role of the objects in gestural interactions was tracking bodily movements rather than undergoing physical manipulations. Study 2 showed that one of the concerns related with user-others interactions was appearance, such as misinterpretation of the gestures by other people in public environment. Therefore, another reason behind why participants preferred using objects as controllers in gestural interactions can be explained with the need of increasing the visibility of the control by involving a tangible element of reference for other people.

**Figure 10** shows how the control of play/pause was performed through gloves sensing the clapping of the hands; the bracelet sensing the muscular movement specific to each hand gesture that corresponds to play and pause in order, from left to right. **Figure 11** shows how volume adjustment was performed through the distance between the two hands and the gesture of



**Figure 8.** Increasing or decreasing the volume through physical manipulations of clothing and accessories



**Figure 9.** Shuffling the songs by shaking the bottle and by creating the skirt



Figure 10. Playing and pausing songs through hand gestures

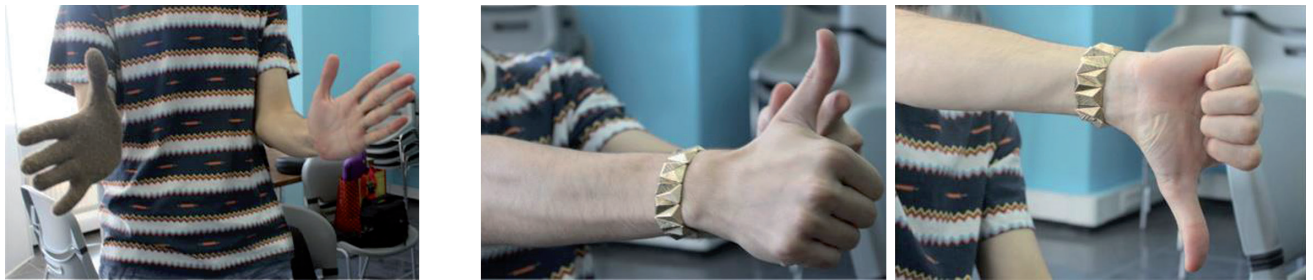


Figure 11. Volume adjustment through hand gestures

Figure 12. Advancing songs with sliding motion of the hand



Figure 13. Controls through foot gestures and controls through proximity of jewellery pieces



thumps up/down. **Figure 12** shows a participant's gesture for advancing songs.

There were also some examples presented by the participants that do not exactly define how specific types of controls can be realized, but they underline the potentials of using particular objects or parts of body for controlling music. **Figure 13** shows the controls through foot gestures tracked by the clip attached to the trousers and controls through proximity of jewellery pieces (the earring and the ring).

### **Exploration of Different Sensorial Interactions**

This section deals with the results of the final stage of the generative session, in which the participants were encouraged to think beyond the capabilities of current technologies and to include other sensory modalities in interaction. Such explorations remained limited to a few examples, but it is worthwhile mentioning to demonstrate the potentials in integrating different sensory modalities to music player controls. For example, one participant used the sense of taste for controls, by building a scenario in which music albums were sold in the form of a pack of biscuits and a particular song in a particular taste started playing when the user tasted the biscuit. In terms of voice control, commands in the form of whistles were offered to control music. There was also an example utilizing the tactile qualities of daily objects, such as touching the roughest surface of a necklace to change the songs.

## **DISCUSSION**

This section offers a discussion on how the aesthetics of music player interactions can be enriched through reinterpretation of personal clothing and accessories, and gestures. It was mentioned that aesthetics of interaction emerges from both bodily interactions and our intellectual reflections on these bodily interactions. Therefore, this discussion first covers the intellectual reflections, in other words, construction of meaning through: i) the relationship between the nature of controls and physical manipulations, and ii) representational relationships. Then, it discusses the qualities of mobile listening devices, clothing, accessories and gestures that help to enrich our bodily/sensorial interactions to construct these meanings; which overall explains the concept of aesthetics of interaction. The discussion concludes with the practical concerns to be considered while referring to these explorations in the design process.

### **Dimensions of Intellectual Enrichment**

#### **The Relationship between the Nature of Controls and Physical Manipulations**


The generative session in Study 3 helped exploring how users' familiarity with physical world can be exploited to conceptualize new interfaces. This was also presented as one of the main strengths of tangible computing by Shaer and Hornecker (2010) and Dourish (2004). The objects provided in the session (mobile listening devices, clothing and accessories) were simulative so that the participants could easily construct new relationships between their physical affordances and music related controls through embodied metaphors. Embodied metaphors can be described as abstractions of physical phenomena. Bakker et al. (2012) exemplify it through the concept of in/out that we internalize through the physical actions like pouring milk out of a bottle or going into a room.

The following section analyses similar meaningful relationships between the nature of controls and the tangible and gestural interactions. The classifications presented in **Table 2** show inspirations for new ways of performing music listening controls as well as their underlying embodied metaphors

**Pause / Play:** These actions were performed by reversing things inside out/inwards outwards, opening or closing, fastening and releasing, tapping, pulling, stretching, pulling and releasing, clapping hands, opening hands. The active and inactive modes of listening were represented with inside/out, open/close (both objects and hands) binaries. They can all be associated with sudden change of the current situation (listening/not listening).

**Skip Back / Forward:** Skipping was realized with pulling the right or left side, tilting something towards right and left, turning something clockwise or counterclockwise direction, and sliding hands towards the right and left. Forward/back was represented with clockwise/counterclockwise or right/left. These actions generally consist of linear movements in horizontal axis and circular movements.

**Volume Up / Down:** They were realized with sliding something up and down, bending (cables), swiping a surface, turning something clockwise/counterclockwise, pointing up and down and opening hands (proximity of the two hands). Up/down was represented as up-down and clockwise-counter-clockwise. The physical manipulations of objects or gestures

| Type of control   | The physical manipulations performed in the generative session for each control                                    |  |   |   |
|---|--|--|---|---|
| Pause / Play<br>           | <br>reversing                   | <br>opening/closing            | <br>tapping/touching       | <br>stretching             |
|   | <br>pulling + releasing         | <br>clapping hands             | <br>opening/closing hands  | <br>opening/closing hands  |
| Skip<br>Back / Forward<br> | <br>pulling the right/left side | <br>tilting towards right/left | <br>turning CW/CCW         | <br>hand waving            |
| Volume<br>Up / Down<br>    | <br>Bending                     | <br>sliding                    | <br>swiping                | <br>turning CW/CCW         |
|   | <br>pointing up/down            | <br>pointing up/down           | <br>opening hands to sides | <br>opening hands to sides |

**Table 2.** Types of physical manipulations performed in the generative session for main listening controls

mainly defined a distance, in other words, the scale of the volume is invisibly or visibly constructed with the proximity of two different means of interaction. Bending cable was an interesting example which goes beyond the concept of up/down or knob-like interactions performed with turning CW/CCW. One participant constructed an analogy between running water in a pipe and the sound as if it literally travels through the cable into our ear and attributed a volume down function to bending the cable. This time the embodied metaphor was derived from the concept of increase/decrease in amount.

Other controls: In shuffle controls the random order of the songs is associated with physical manipulations and gestures which create a messy look such as creasing (the skirt), shaking (bottle), and scattering (hair).

#### Representational Relationships

During the generative session, it was observed that daily objects were used not only as means to control but also to provide new representational relationships. Using different pieces of jewellery set as controllers of gestural interface also brought the idea of presenting a set of jewellery as the playlist or an album with a specific genre. Some participants associated the pearl with classical music, and iron/steel with metal music. As well as this material-genre correlation, another example is based on the idea of taste-album relationship, in which an album is released in the form a biscuit, and every song with its own taste starts to play when the user starts to chew it. These scenarios can be regarded as reincarnation of physical music storage media which became obsolete with the introduction of MP3 in different forms. This means that for example, a necklace, t-shirt, dress can be designed to access and manipulate particular type of data (the album/playlist/song).

#### **Dimensions of Sensorial Enrichment: The Different Roles of Physicality in Formulation of the New Aesthetics of Music Player Interactions**

We have discussed how the use of personal clothing and accessories contributes to experience of meaning through the use of embodied metaphors and representational relationships. This section elaborates on how the use of these items contributed to aesthetics of interaction through reinterpretation of physical affordances, use of material properties, and use of spatio-temporal relationships.

1. Reinterpretation of physical affordances: The variety of personal clothing and accessories multiplied the ways of physical encounter through varied affordances and helped the participants to construct rich meaningful relationships with the products. Using a circular brooch to skip back/forward by turning it CW/CWW is just one example of reinterpretation of physical affordances.
2. Use of material properties: Material properties (texture, deformability, elasticity etc.) can be inviting to perform certain actions as much as the affordances that stem from the shape or form of the products. It can be exemplified with touching the roughest surface of the necklace to switch from the normal play mode to shuffle mode (texture) or bending the cable to increase/decrease volume (deformability).
3. Use of spatio-temporal relationships: It can be exemplified with the change of places (using the clothing as a lay-out for different

functions/options by changing the place that MP3 player is attached to the clothing to change the playlist), proximity between different items (controls based on the distance between the earring and ring), moving up/down or right/left (sliding hands to skip songs) and creation of a tangible list (pulling the measure tape until the ninth song (nine cm long) and play it by releasing). The speed or repetition of the physical manipulations/gestures as in the example of shuffling through shaking can also be considered as the use of spatio-temporal relationships.

These three dimensions of sensorial enrichment are based on the physical phenomena. However, social affordances can also be inspirational in design of aesthetics of interactions. The daily objects and the way we use them all have social roles. For example, wearing headphones in public context can give the message of I am not available to communicate. Besides, as revealed in Study 2, the social occasions or activities (social encounters, conversations) can afford us to use or physically manipulate objects in certain ways; such as the reflex of taking off headphones instead of bothering with finding the pause button/icon when we start talking with someone. In the categories of 'controls performed beyond the designed interface of available mobile listening products', 'utilization of the objects already involved in accompanying activities' (Table 2), we observed such effect of social affordances in finding new ways of interactions. This can be exemplified by the demand of an automatic pause of the song when the purse is opened in the moment of a purchase (Figure 5) or when the headphone is taken off in the moment of a conversation.

### **Practical Concerns to Be Addressed in Embodied Music Player Interactions and Design Strategies**

The disadvantages of different types of embodied interaction have been mentioned earlier; such as user fatigue, rigidity of TUIs, need of visual affordances for gestures. This section specifies the practical concerns regarding embodied interactions based on the case of mobile listening in public environment. It also borrows the user concerns from Study 2 (proximity, listener's appearance to others) to reflect on the performances presented in Study 3. It identifies the critical points that designers need to consider while bringing such explorations into life and discusses the potential design strategies to tackle each concern.

Challenges in reinterpretation of physical affordances: The differentiation between the pre-established and new functions assigned to a physical affordance can sometimes be problematic for users; like in the example of increasing the volume by using the zip of the jacket.

The design strategy to eliminate such confusion while maintaining the desired interaction aesthetics can be to look at the underlying embodied metaphors (levelling up/down) and apply it in different forms in a way that it won't repeat the pre-established function of that specific physical manipulation.

Prevention of accidental controls: Some physical manipulations and gestures can cause some accidental controls when specific actions defined for the control is performed for another reason or unintentionally. For example, sudden taps can be regarded as pause/play although unintended.



The solution to avoid such situations relies on the use of new parameters for physicality. Determining the duration of the control (the duration of touch, stretching), determining the amount of physical change or force (the amount of creasing, the force of tapping), identifying the control area (differentiation with the textural and visual properties), or determining the frequency or number of repetition of the action can deal with the problem of accidental controls, or the differentiation of controls from other instrumental/non-instrumental actions. Therefore, feedbacks and feedforwards become more important considering how designers should communicate how long a surface is pressed, how long an object is stretched, how far / how fast an object is moved.

**Physical Constraints:** Controls demanding the use of two hands together such as bending cables to decrease volume may be technologically feasible but pose problems in occasions such as standing in a bus or carrying bags. Similarly, gestures that require a certain 3D space to be performed can be problematic considering the intensely crowded public settings (proximity). As mentioned earlier, user fatigue is another physical constraint which might result from repetitive physical manipulations.

The strategy to deal with these physical constraints can be to provide flexibility to users that they can also control the music player in a way that it relies less on the use of space and body. Whether the solution is a replacement or an additional form of control, the underlying embodied metaphor (bending the cable-manipulating the flow-adjusting the volume) can still constitute a reference.

**Social Acceptability:** Results of Study 2 showed that one of the concerns related with user-others interactions was appearance (if the product looks like an accessory or a device, if its typology or interaction is unprecedented to other people). In Study 3 the participants also felt reluctant when they were asked to perform the controls through their bodily movements or gestures. This reluctance can be explained with the possibility that other people in public environment may not understand the gestures or associate different meanings to these gestures rather than their intended function; which may create an awkward situation.

One strategy to design socially acceptable embodied music player interactions can be built on the preferences of the participants of Study 3. One of the reasons behind why participants mostly preferred using objects in gestural controls as controllers can be explained with need of increasing the visibility of the control by involving a tangible element of reference for other people. As an external reference, in their study on eyes-free continuous input on interactive clothing, Karrer et al. (2011) discuss that exploiting the common clothing interactions can establish a baseline for acceptable gestures. Therefore, physical items can be integrated to the gesture-based interaction in the public context whether/not their material qualities constitute the main means of the interaction aesthetics.

## CONCLUSIONS

This paper argued that, while designing (aesthetics of) interactions, the integration of digital technologies with physical items (as in the example of wearable computing) should be discussed through the contributions of both digital and physical domains to each other. Having acknowledged the role of digital technologies in expansion of the expressive characteristics of the physical items, the paper explored the role of embodiment in

enrichment of interaction aesthetics of digital systems through the case of mobile listening experience in public environment. Choosing mobile listening as a case enabled the search of aesthetics of interaction possibilities with personal clothing and accessories that accompany users in their public journeys with music. Therefore, it presented the generative session -Dreaming about the Journey- where participants were asked to rethink music player interactions through physical manipulations of available mobile devices, personal clothing and accessories as well as their gestures. The contributions of the paper on the design of embodied mobile music player interactions include the following:

- A new methodological approach which appropriates the previous practices of generative sessions and embodied imagination for conceptual development of new interfaces based on embodied interaction: In this research, the role of the physical toolkits that are used in generative sessions is extended in a way that they are not only for making a model of the dream product but also to explore new embodied interactions through personal clothing and accessories, which are potential items of the use context. Another contribution of this approach is that performances can be observed and recorded by the design researcher in an isolated venue while there is still a use of embodied imagination with reference to the public context. This is thanks to the multi-partite research organization that integrates in-situ experience for the participants before the generative session.
- Identification of different approaches to follow in utilization of physicality in mobile music player interactions: The analysis of Study 3 drew some categories for the ways the participants re-conceptualized available mobile devices, clothing, accessories and their gestures to interact with music players (**Table 2**). These categories are useful for designers of embodied interactions because they present different approaches to be followed in intersection of the digital domain and the physical domain (personal clothing and accessories): For example, utilization of these physical items can emerge only as defining accessible control spaces on the clothing (**Figure 4**); whereas there are more sophisticated ways of interpreting the physicality, such as using deformability of the textile by creasing the skirt to shuffle (**Figure 9**). The categories like of controls performed beyond the interface of available music players also confirmed that the social affordances can demand control options like an automatic pause of the song when the headphone is taken off during a conversation.

The practical concerns that are likely to emerge in interpretation of these approaches in future mobile music players/controls are (1) reinterpretation of the potential physical affordances that have been already used for pre-established functions, (2) prevention of accidental controls, (3) physical constraints and (4) social acceptability. The design strategies to tackle these practical concerns can be summarized as alternating the manipulations by keeping the underlying embodied metaphors, definition of other parameters for aesthetics of interaction (setting durations, amount of force applied), providing flexibility in controls and integration of physical accessories in interaction to make gestures perceived as controls of a device or non-instrumental natural interactions.

- Identification of the dimensions of intellectual and sensorial enrichment of the mobile music player interactions: The outcomes of the study demonstrate that embodiment of personal clothing and accessories enriched music player interactions both in sensorial and intellectual ways; both of which contributes to aesthetics of interaction. The sensorial enrichment was explained with the dimensions i) reinterpretation of physical affordances, ii) use of material properties, and iii) use of spatio-temporal relationships. Each dimension can be further elaborated by designers to multiply the ways we interact with music players (what other material qualities than the ones presented here are potential means of specific interactions). When the action possibilities are enriched with the above-mentioned dimensions, the meanings that users construct while using interactive systems are also enriched. The intellectual enrichment was explained through i) the embodied metaphors and ii) the representational relationships. They can also guide designers to extend the physical affordances, materials, spatio-temporal relations mentioned in the paper to find new embodied interaction types to match the intended meaning with new sensory interactions.

The contributions of this paper are not limited to case of mobile listening although the contributions are listed with reference to the music player interactions. First, the present methodology can be used for embodied interaction design concepts development by conducting the Do stage of Say-Do-Make in a relevant context and then continuing with the generative design session (Make) in presence of the researcher with selection of the physical toolkit from the items are more appropriate to that use context. Second, although the examples for utilization of physicality in music player interactions may not be applicable for all user interfaces, the conceptual categorization of these examples and identification of the dimensions of sensorial and intellectual enrichment make the outcomes more generalizable for the design of other user interfaces. For example, the category of reinterpretation of non-instrumental interactions as controls can encourage designers to exploit other potential non-instrumental interactions for more disguised embodied interactions in public context. Similarly, the sensorial enrichment through the use of material properties can invite designers to consider the changes in any material property as changes in status of any device. Third, the practical concerns discussed within the paper is expected to be relevant for other embodied interaction concepts or other mobile devices to be used in public.

Further research can extend the scope of the present study by involving all listening-related controls and feedbacks with different complexities that would demand considering different types of interfaces together. The outcomes of the paper can also be furthered with the transformation of the examples presented in Study 3 into working prototypes; and then testing them in a literal journey (as in Study 2). This would enable a comparative analysis of contemporary products (interfaces) with proposed ideas.

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## **MOBİL MÜZİK ÇALARLARIN SUNDUĞU ETKİLEŞİM ESTETİĞİNİN ZENGİNLEŞTİRİLMESİNDE KİŞİSEL GİYSİ VE AKSESUARLARIN BİR ARAYÜZ OLARAK KULLANILMASI**

Dijital teknolojilerin fiziksel çevremizle bütünleşmesi gittikçe artmaktadır. Dijital teknolojiler fiziksel nesnelere ifade biçimlerini zenginleştirmiştir, ancak bu bütünleşmede fizikselliğin dijital sistemlerle olan etkileşimimize nasıl katkı sunduğu da tartışılmalıdır. Bu makale bu tartışmayı mobil müzik dinleme deneyimi bağlamında sunmakta; kişisel giysi ve aksesuarlarımızın mobil müzik çalar arayüzünün bir parçası olarak düşünülmesi durumunda bunun etkileşim estetiğini nasıl zenginleştireceğini incelemektedir. Bu kapsamda, katılımcıların bu nesnelere fiziksel olarak manipüle ederek müzik çalarlarla olan etkileşimlerini yeniden düşünüp sergiledikleri bir yaratıcı tasarım oturumu sunulmaktadır. Çalışma fiziksel nesnelere ve hareketlerin dijital sistemlerin arayüzü olarak kullanılması hususunda farklı örnekler ortaya koymuştur. Bu örnekler kişisel giysi ve aksesuarların müzik çalar kontrollerinin yerleştirileceği alanlar olarak kullanılmasından, malzeme özelliklerinin kontrol aracı olarak değerlendirildiği daha karmaşık fiziksel manipülasyonlara kadar değişik yaklaşımlar içermektedir. Bu çalışma kişisel giysi ve aksesuarlar mobil müzik çalar etkileşiminin bir parçası olarak değerlendirildiğinde hem duyuşsal hem anlamsal etkileşimin zenginleştiğini göstermektedir. Etkileşim estetiğindeki bu zenginleşme fiziksel nesnelere barındırdığı sağlanabilirlikler (*affordances*) ve malzeme özelliklerinin kullanıcılar tarafından yeniden yorumlanması ve yeni zamansal-mekânsal ilişkilerle açıklanabilir. Bunlara ek olarak, anlamsal zenginleşme fiziksel metaforların kullanımı ve yeni temsili ilişkilerin kurulması ile mümkün olmuştur. Makale, son olarak, katılımcıların yaratıcı tasarım oturumu sırasında sergiledikleri farklı yaklaşımların gelecek mobil müzik çalar arayüzleri için değerlendirilmesinde ortaya çıkabilecek sorunları tartışmakta ve bunlar için birtakım tasarım stratejileri sunmaktadır. Bu stratejiler, çalışmada sunulan örneklere alternatif fiziksel sağlanabilirlik geliştirilirken bu örneklerin altında yatan fiziksel metaforların korunması, kullanıcı isteği dışındaki kontrollerin engellenmesi amacıyla kontroller için ek parametreler tanımlanması, kullanım bağlamındaki değişikliklere yönelik kullanıcıya birden fazla kontrol biçiminin sunulması ve kamusal alanda mimiklerle etkileşimi daha kabul edilebilir kılmak adına fiziksel nesnelere kullanım senaryosuna dâhil edilmesi olarak özetlenebilir.

### ENRICHING THE AESTHETICS OF MOBILE MUSIC PLAYER INTERACTIONS THROUGH THE USE OF PERSONAL CLOTHING AND ACCESSORIES AS INTERFACES

There is growing integration of digital technologies to the physical domain. In this process digital technologies have expanded the expressive characteristics of physical products. However, in this integration, we should also discuss the way that physicality enriches our interactions with digital systems. This paper aims to attend to this discussion through mobile listening experience and explores how embodiment of personal clothing and accessories can enrich the aesthetics of mobile music player interactions. It presents a generative session where participants were asked to rethink and perform particular music player controls through physical manipulation of personal clothing and accessories as well as gestures. The outcomes of the study reveal different examples (to be) followed in the integration of digital technologies with personal clothing and accessories. These examples comprise a variety of approaches ranging from depiction of potential areas on these physical items to attach controls to more complex physical manipulations where their material qualities are used as a means of music player controls. The study demonstrates that the use of personal clothing and accessories as interfaces contributes to both sensorial and intellectual enrichment of music player interactions. The sensorial enrichment can be explained with the interaction possibilities expanded by reinterpretation of physical affordances, use of material properties and use of spatio-temporal relationships. In addition, the intellectual enrichment is achieved with users' construction of meaning through embodied metaphors and representational relationships. The paper finally discusses the practical concerns that are likely to emerge in the interpretation of different approaches presented in the generative session while developing future mobile music player interfaces. The paper also provides design strategies to tackle these concerns. These strategies can be summarised as keeping the underlying embodied metaphors when developing alternatives for physical manipulations that have pre-established functions, defining additional parameters for aesthetics of interaction to prevent accidental controls, increasing the control options to adapt to changes in use context, and integrating physical accessories and clothing into the use scenario to make gestures socially more acceptable.

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