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Perception, Meaning and Transmodal Design

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Abstract: Our perceptual system allows us to experience and make meaning of the world through different modalities. We can move between feeling, seeing and hearing things and still makes sense of our world. Our cognitive activities are transmodal. In interaction design this means that both our design processes and our users' interactions are transmodal. We have gained insights into how transitions between modalities, both in the design context and in the users' interaction context, modulate meaning and experience, by analysing three interactive systems: SimProv, VibEd, and Sightlence. We propose that a transmodal design approach facilitate designers to realize the communicative potential of different modalities, and hence present users with a transmodal perspective on their interaction space that allow for continuous rearrangement and use of modalities.

Keywords: situated cognition; transmodal design; transmodality; interaction design

1. Introduction

Making appropriate use of different modalities and translating between them in design can facilitate understanding, make information more accessible, improve communication, stimulate critique, and improve inclusion of, for example, people with sensory disabilities.

In interaction design, multimodality has been a highly active research topic for decades (Turk, 2014). Multimodality, in that tradition is however mostly a computer input issue (e.g. keyboards, mouse, speech, touch), even though computer output modalities also have been considered. It is in the multimodal user interface research, not as much about expressing the same content or meaning in different modalities, or translating between them, but rather how they can supplement each other to increase users' immersion or proficiency (Nesbitt & Hoskens, 2008). An example of that would be a virtual cave environment with real-time 3D graphics, audio stimuli (ambient, static, and event sounds), and haptics (wind and tactile feedback when touching objects) (Fröhlich & Wachsmuth, 2013). Furthermore, the design process that is needed to create multimodal interactive systems has generally not been addressed.

The notion of multimodality can be contrasted to what we call transmodality, in which we focus on how different modalities not only supplement each other but also sequentially perforate and interpenetrate each other (Murphy, 2012). Transmodality concerns a kind of translation or transposition over time where meaning is modulated in the movements between modalities with different communication potentials. An example of a transmodal shift in interaction design is if ambient background sounds would be transposed to visual form as a user brings a background object into focal attention. A question is then how continuity of meaning and experience is preserved. This points also towards a conceptualization of interaction design as a process by which the designer presents a user with a perspective on their interaction space, referring some objects and aspects into the user's focus and others to the background (Arvola, 2014).

The perspective is then rearranged dynamically in interaction. Multimodal design has other concerns. Oviatt (1999) describes a number of myths concerning multimodal interaction with one myth being that multimodal integration involves redundancy of content between modes. Based on this, Turk (2013) concludes that complementarity of content between modalities may be a more important consideration for multimodal system design. Whereas multimodal design focuses on input and supplementary modalities, transmodal design deals with content that is translated between modalities as an activity evolves.

Turning from product to process, Murphy (2012) has described how transmodality can operate in a product design process spanning a few days, and Arvola and Artman (2007) have given examples of how iconic gestures representing design ideas were transformed into visual and verbal concept descriptions. Transmodality in design processes can also encompass much larger time spans. An example of that, in the domain of interactive systems, is that games before computers always have been multisensory experiences, but in the first computer games they became primarily visual, before sound was introduced again and primitive forms of haptics entered at a much later stage.

In this paper we will argue that transmodality operates both in the actions, and processes involved in a designer's work, and in a user's interactions that the designers target to shape.

2. Perception and Meaning in Translations between Modalities

Transmodality involves accordingly the mechanisms by which content is transformed to be presented and perceived by means of one or another of our sensory modalities. This points towards epistemological considerations about how we can gain information about the world through perception, and towards phenomenological considerations about the conscious and continuous experience and meaning of perception at a semiotic level.

From our intuitive first-person understanding of what it means to perceive the world around us, Fish (2010) proposes three key principles to structure an analysis of different theories of perception: the common factor principle, the phenomenal principle, and the representational principle.

The common factor principle separates the mental state or event of perceiving something from the material properties of that which is perceived, and also claims that there is a commonality between all mental states or events that are experienced as identical by a perceiver regardless of the actual material properties of that which is perceived (Fish, 2010). Fish distinguishes between three ways of perceiving something with varying success: perception, to perceive a thing as it is; illusion, to perceive a thing as it is not; and hallucination, to perceive a thing that is not.

The phenomenal principle states that perception is about something that is experienced. That something has felt qualities—qualia—that can either be conceptualized as sense data or as more complex experienced qualities that are actively searched for.

The representational principle states that perceptions have content and are about something beyond themselves. This means that the things that meet our senses, regardless of modality, are meaningful and made sense of.

We need to address the three principles to understand transmodality in design. First, we need to consider how to design for people to perceive things as they are, as they are not, or perhaps also perceive things that are not. We can, in intersemiotic translation (Jakobson, 1959) between modalities, address what is lost in how things are, how we introduce distortions in perceptions of things, or even perceptions of things that do not exist. In doing so we should consider if the phenomenon is perceived with the same experienced qualities or how it has changed in the transition between modalities. Finally, we need to think about how we represent things and what aspects of it that are represented, and what its meaning is. The representational principle also points towards the semiotic aspects of transmodality.

In interaction design the material is dynamic, computational and abstract in its essence. The written program code, its subsequent presentation in runtime behaviour and interface for human interaction, can be conceptualised as signs. Using Pierce's model, a sign consists of three parts: a representamen, an interpretant, and an object. The representamen is the sign's shape, the interpretant is the sense made of the sign, and the object that exists beyond the sign is its referent (Chandler, 2007).

The user interface of an interactive system can be conceptualised of as representamen that signifies the object, which is the computational objects, processes and events in the computer. The interpretant is a designer when designing the system, and a user when using the system, and their reactions in their respective contexts. The interpretant specifies a relation between the representamen and the object, which gives rise to meaning. The objects and events in the computer are signified by the user interface in the context of, for example, the designer or in the context of the user (Kindborg, 2003). This means that user interfaces are conceived as signs made by designers and taken by users to be expressions the designers' intent and of the inner states of an interactive system (de Souza & Leitão, 2009). The interpretant of one sign may in turn be a sign that refers to some other object for another interpretant. For example, the sense made by a user may be taken as a sign that refer to a sub-optimal design solution for the designer. Or visa versa, the sense a designer make of computational events, becomes a representamen in a user interface for a user. Designing transmodal transformations in user interfaces thus involves traversing and understanding different interpretant contexts to successfully create a new representamen in another modality while keeping essential aspects of the interpretant intact. Similarly, understanding transmodal transformations in design processes, requires an analysis that take the movement across interpretant contexts during the semiosis into account.

In a transmodal transformation between, for example, a textual and a visual representamen of an object there is also a possibility that a sign vehicle changes the sign category. It could, for example, in text be a symbol with an abstract connection to the object, but in a transmodal translation turn into an icon that resemble its object in some sense. In a transition between modalities, a symbol or icon could potentially also turn into an index, which is directly connected to the object it refers to.

3. Transmodality

It is well established in multimodal communication and interaction that meaning is collaboratively produced in a complex of talk, embodied action (e.g. gesture), and physical as well as social and temporal context (e.g. Goodwin, 2000; Streeck, Goodwin, LeBaron, 2011). However, little effort has been placed on the intricate ways in which sensory modalities (seeing – drawing, hearing – saying, moving – touching, etc.) integrate, affect, and transform each other during the course of an activity. To address this gap, Murphy (2012) introduced the notion of transmodality as a component of the multimodality framework. He studied product design activities with a focus on “the sequential generation of linked semiotic chains over relatively long stretches of discontinuous time (Murphy, 2012, p. 1967).” By “relatively long stretches of time” he referred to a process in which an abstract idea of a candleholder was transformed into a concrete prototype across many interactions that spanned several days. The notion of transmodality brings to the analysis a perspective of how different modalities not only supplement each other, but also sequentially perforate and interpenetrate each other. Over time, the meanings expressed in one modality, dynamically blend and shape what is expressed in other modalities. This produces, according to Murphy (p. 1969), “a series of semiotic modulations in which certain core qualities persist, but others are noticeably transformed in the transition from one mode to another.” The modulations can include movement, mutation, and amplification.

Transmodality can, according to Murphy, also be described in terms of a translation that involves transformative procedures that operate on different aspects of the original code, as for example forms, grammar, etc. The transformative procedures produce new patterns of semiosis that still have elements of the source material that can be recognized even though the core meaning is expressed in different ways.

In face-to-face-interaction, transmodality takes place through sequential chains of utterances and gestures, that enact the production of meaning as verbally expressed ideas that subsequently materialised as gestures, notes, or rephrased utterances. Transmodality can however operate across longer time spans and across different media and people.

The central question for this paper is how transitions between modalities both in the design context and in the users' interaction context modulate meaning and experience. The focus is not only on small pieces of interaction, but also extended periods of time in a design project. This opens opportunities to study semiotic modulations that are dislocated in time, but still influences the meaning and experience of design.

4. Transmodal Design

The context of a design activity can be transmodal, as shown by Murphy (2012), as well as by Arvola and Artman (2007). The context of users' interaction with the resulting product can however also be transmodal. For example, fire fighters that enter a smoke-filled house can no longer rely on visual maps and visual perception for navigation but have to feel their way forward with their sense of touch, which is an atypical way of navigating spatial space. Adaptive user interfaces can support the user by changing the interface modality used to present information. This would be a clear change compared to contemporary user interfaces as they primarily rely on the visual modality to present content and enable communication. Desktop computers use audio for content delivery in the form of music and movies, but their user interfaces are mostly graphical, and the haptic modality is practically absent. Mobile phones and video game consoles contain simpler vibrotactile actuators that are used to a limited extent. User interfaces can be considered transmodal when they can transform information across different modalities without loosing essential meaning when doing so. Transmodal design concerns itself with those situations where such transformations are beneficial or necessary.

In the following section we describe three systems that were designed with transmodality in mind. The first system, SimProv, was designed in different versions that make use of different modalities. The second system, VibEd, is a visual editor for prototyping haptic interfaces. The third system, Sightlence, is a computer game that can be played through any combination of graphic, audio, and haptic modalities.

4.1. SimProv

SimProv is an education simulation for pre-service teachers' leadership development. A part of the pedagogical idea of the simulation is that the pre-service teachers explore it together in pairs. The content consists of scenarios that feature common problematic leadership situations that teachers often encounter in their classroom. The pre-service teachers engage with the content through reflective discussion of suitable approaches, deciding on a course of action, evaluating the scenario, and exploring alternative approaches. The scenarios are based on longitudinal studies of classroom life. The different prototypes of SimProv variously present the scenarios through texts, radio theatre, still images, three-dimensional game spaces, and combinations thereof.

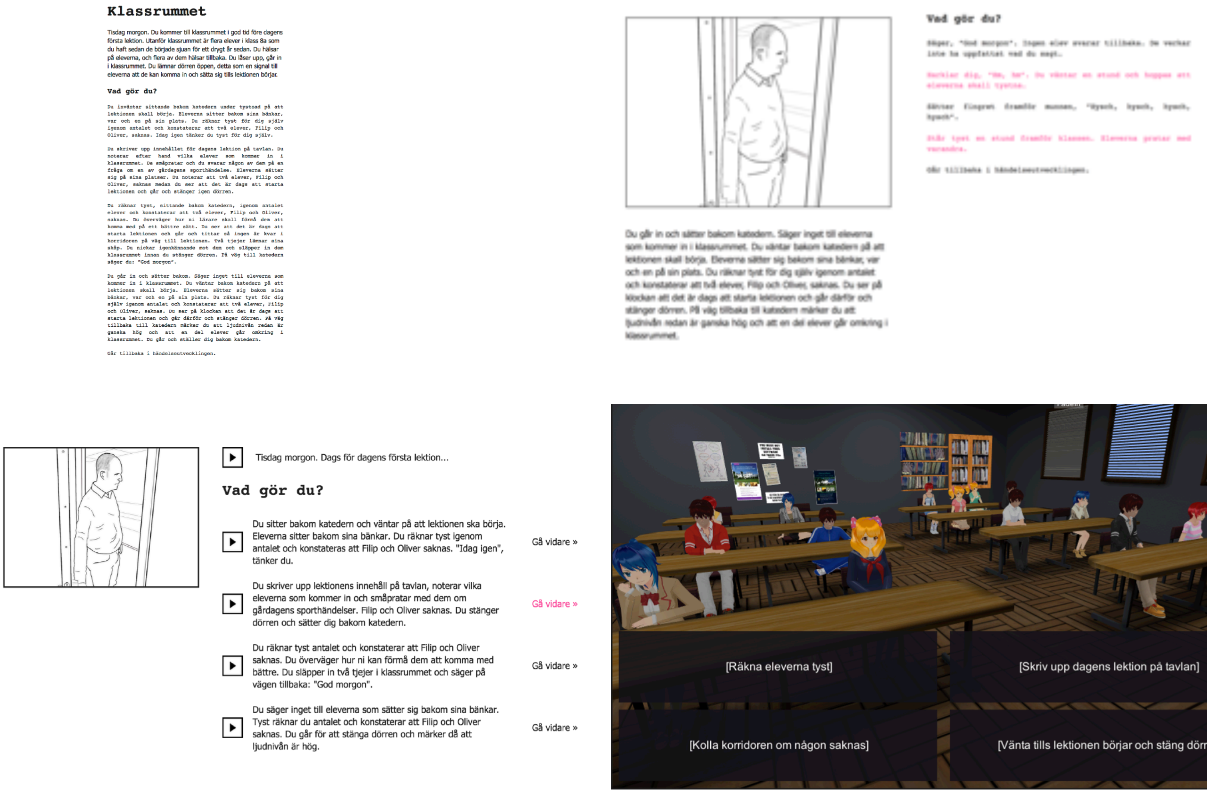

Figure 1 Stages of SimProv. The first text-based prototype turned into a second prototype that also included still images. A third prototype added audio and changed the focus to radio theatre. A fourth prototype explored the use of three-dimensional space.

Figure 1 shows SimProv prototypes that were built to explore various ways of presenting the simulation content for the pre-service teachers. The first prototype was entirely based on text and focused on getting the wording, flow, and description of the scenarios right, so pre-service teachers would find them authentic, as well as exploring different formats for the pre-service teachers to engage with the scenarios. The second prototype took its basis in the first one but added still images to the scenarios in order to highlight various aspects of the texts. The third prototype changed focus from text by rewriting them to be shorter and sparser, and instead added an audio modality by recording the scenarios in the form of radio theatre. A fourth prototype rewrote the scenarios by removing all text that was not focused on dialogue and modelled a three-dimensional space with avatars that presented the dialogue in a more game like form.

During the design process, the written scenarios were illustrated, which meant that features that had never been described in the text suddenly became stated. Features such as the age and gender of the teacher now became part of the scenarios through the still images instead of being left to the pre-service teacher’s imagination. The prototype that explored audio through radio theatre made it possible to not only express what people said but also how they said it with more nuance, which in some cases created differences of impression between the teacher's behaviour as written in the text compared to as it was acted out in the radio theatre. These differences in modality presentations afford both opportunities, and aspects of normativity that need to be considered in the design of scenarios for educational simulations. We are currently investigating the relative merits of text, still images, audio, and spatial environments for information quality in SimProv (Nordvall, Arvola & Samuelsson, 2014).

4.3. VibEd

VibEd is an editor for designing haptic interfaces for productivity software and computer games intended for personal computers, game consoles, and mobile phones. It visualises haptic signals in a manner similar to how Digital Audio Workstations visualise audio signals. By transforming the signals into the graphic modality they can be displayed on computer monitors. Through this transformation these two modalities become available as design materials that can be used and shaped with the same hardware, and peripherals as those that are used when working with graphics or written language.

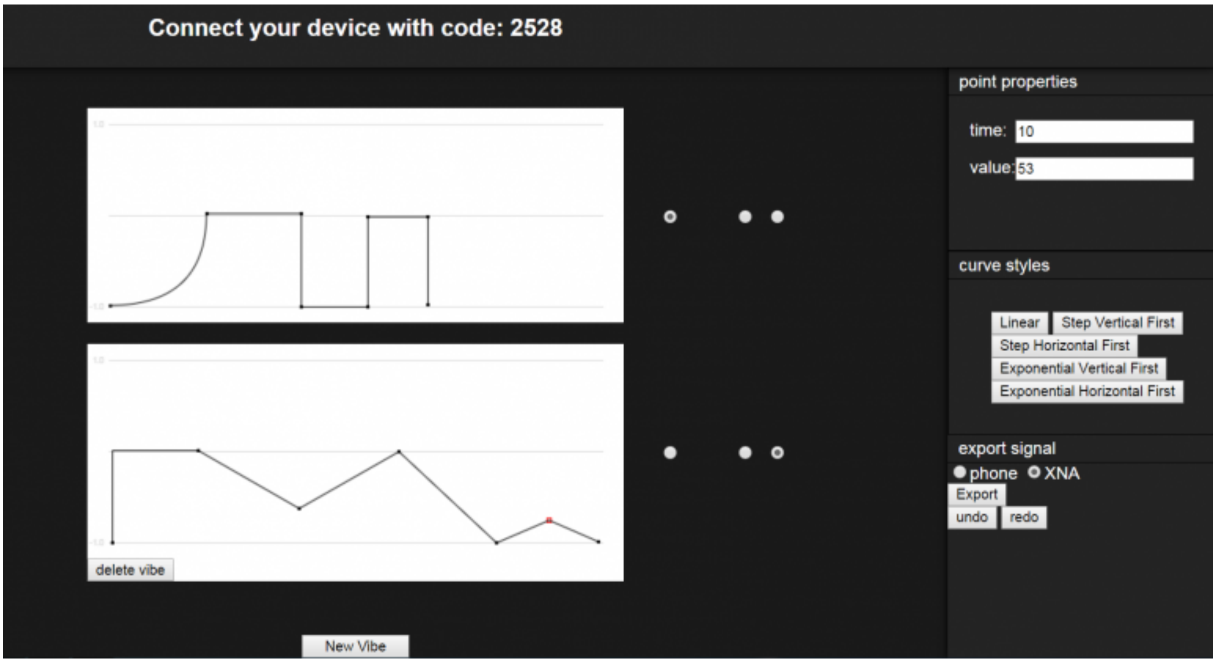

Figure 2 Visually expressed vibrotactile signal patterns in the VibEd system. The different signals represent different vibrations with regard to amplitude, duration, and rhythm.

VibEd allow designers to create haptic signals intended for vibrotactile actuators by drawing visual descriptions of their amplitude, duration, and rhythm. The designed signals can then be tested immediately on a gamepad or smartphone thanks to companion apps, and if they are satisfactory they can be exported as code for use in development. Exported haptic signals needs to be hardware platform specific since there is a large variability in the control different platforms offer developers over the parameters of their haptic actuators. How to convey the communication potential available on a particular hardware platform as a result of the hardware quality of, and software access to, its actuators remains an open issue.

Another open design issue that concerns how editing tools that visually work with the haptic modality are to show and integrate the parameters that can be used in the composition of a haptic signal for a computer interface. The haptic modality has similarities to both audio and to graphics, and similarities impose restrictions on the possible design solutions that can be used to visualize it. The haptic modality shares similarities with audio in the temporal aspects as a particular signal can be described through the parameters of frequency, amplitude, waveform, duration, and rhythm. It also shares similarities with graphics in that it has spatial aspects that can be described in the form of location and surface area. These can in turn form spatiotemporal patterns, which have always been a challenge to represent as a single static two dimensional image in order to give overview. This is the reason for why the haptic modality is problematic to visualize since its temporal aspects must be given spatial form in a space that is already occupied by its spatial aspects.

4.2. Sightlence

Sightlence is a transmodal user interface redesign of the classic computer game Pong. It is a conceptual variant of table tennis. Two players control a paddle each that can be moved vertically up and down across the screen. The goal of the game is to successfully hit a ball that travels back and fort across the screen. The players score points when the other player miss the ball. The user interface redesign makes the game information normally presented with the graphic modality in Pong available through the audio and haptic modalities as well. This redesign also makes the game accessible for people with blindness and deafblindness (Nordvall & Boström, 2013; Nordvall, 2014).

The redesign was done by analysing how the objects, rules, game mechanics, and interaction of Pong were presented to the players visually. Because of the limited resolution of the vibrotactile actuators in the Xbox 360's gamepads it was necessary to design haptic modality translations that were based on symbolic signs more closely corresponding with spoken language as the technical limitations of the gamepads make it hard to design haptic signs that incorporate iconic or indexical aspects. Even though audio speakers in general have superior audio resolution compared to the haptic resolution of game console gamepads, the same approach was used for the design of Sightlence's audio interface as well. The haptic and audio interfaces therefore have some commonalities with each other compared to the graphic interface.

The monitor displays the game objects graphically while their relationships are implied through the dynamically changing white space between the objects. For the haptic and audio interfaces the players' perception of figure and ground is reversed, and the relationships in the game becomes explicit while the game objects recede to an implied existence. Both interfaces have a signal that signifies a shrinking distance but they leave it to the players to infer the particulars of the game objects that are involved. The players must therefore go through a dual process of both learning the rules and game mechanics of the game, and also learning the symbolic language of the audio and haptic interfaces in order to interpret its information output successfully.

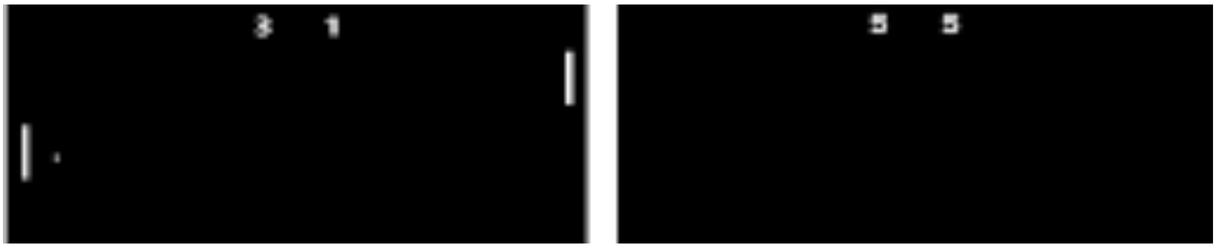

Figure 3 Sightlence with and without graphics. In the haptic-only mode, only the score is represented visually on screen while the rest of the objects, rules, and game mechanics are conveyed through the haptic modality.

Sightlence is played with two Xbox 360 gamepads for each player since the vibrotactile actuators in the gamepads have limited resolution. One gamepad is held in the hands and is used for both the player’s input, and for interface output. The other gamepad is placed in the player’s lap and is only used for interface output. Vibrotactile signals from the gamepad held in the hands represent the spatial location of the ball relative to the player’s paddle through a steady vibration with a low amplitude when the ball is above the paddle, and with high amplitude when the ball is below the paddle. The vibrotactile vibration is silent when the two game objects are horizontally level with each other. Short low frequency signals of high and low amplitude play when the ball hits the player’s paddle, and their opponent’s paddle, respectively. Vibrotactile signals from the gamepad resting on the lap increases steadily in amplitude as the ball approaches the player, and decreases as it retreats. Short low frequency signals of high and low amplitude are played through the lap gamepad when the ball hits the upper and lower edges of the screen. A rhythmic vibrotactile signals is played through both gamepads when a player scores a point. An evaluation of Sightlence shows that the game is just as fun to play with the haptic modality even though it is much harder to play proficiently (Thellman, 2013).

5. Maintaining and Revealing Meaning in Transmodal Modulations

This paper’s central question is how transitions between modalities modulate meaning and experience in both the design context, and in the users’ interaction context.

The transmodal changes in SimProv happened over extended periods of time as the prototypes not only moved between interface modalities but also between iterative development phases focusing on design, writing, illustration, and audio production. The transmodal nature of this design process created signs in different modalities, which resulted in variations of representamens and interpretants across the prototypes. The modality translations in VibEd were more straightforward as they move between the visual and the haptic modalities. They do highlight the need for the design process to be sensitive though to differences between the parameters of modalities, and the expressive capacity of different platforms' actuators. The haptic signals that can be designed in VibEd are the representamens that make up Sightlence's haptic interface. The game's interface translations between the graphic, audio, and haptic modalities can therefore be thought of as an attempt to change the representamens of the game's interface while keeping the interpretant intact. Pong was originally played primarily through its graphical interface but the translations should not be seen as translations from the graphic modality to the audio, and haptic modalities. All three modalities are used to create interfaces that allow the players to understand and interact with the machine code that's running invisibly inside the computer, and that's how the modality translations should be understood.

Murphy (2012) notes that transmodality gives rise to movement, mutation and amplification. We could observe such aspects in SimProv as meaning and experience were amplified in some modality translations, while others were mutated as a modality could be more specific in some aspects and less in others. The visual representamen in VibEd had a greater expressiveness than the expressiveness of the vibrotactile actuators in mobile phones, which gave rise to mutations in the form of filtering effects. The interface modalities in Sightlence also experienced mutations as the game objects' figure-ground position changed from being explicitly displayed semiotic icons in the graphic interface to becoming indexes of events instead in the audio, and haptic interfaces as the representamens of the latter two interfaces' made the relationships between game objects explicit while the game objects themselves became implied. These mutations are interesting examples of changes that happen in intersemiotic translations between sign systems (Jakobson, 1959).

Opportunities for future investigations into transmodal design include explorations of how transmodal interfaces can provide ambient background information in one modality and then transform the information into another modality as the user's attention shifts between different information sources; how transmodal interfaces can move between and combine multiple modalities during the user's continuous interaction flow; and how continuity in experience and meaning is maintained during modality shifts. Answering questions such as these will have implications both for inclusive design for people with sensory impairments, and for the design of adaptive and context aware user interfaces.

Transmodal design contributes to the understanding of the active role that the interactive and dynamic computer medium plays in the production of meaning in action. It also contributes to the understanding of interaction design as a multimodal design practice since a transmodal design approach encourage designers to realize the communicative potential of different interface modalities.

It has been suggested that interaction design can be conceived as suggesting a perspective on an interaction space, that users rearrange in action according to current objects of interest (Arvola, 2014). The perspective on the interaction space places some objects and aspects in focus, and other objects and aspects in the background. The notion of transmodal design highlights that the rearrangement of the perspective on the interaction space includes shifts between modalities and also modulations of experience and meaning.

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