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# Multimodales Design

## Multimodality in Design of Tangible Systems

Design\_tangible interaction\_multimodality\_elderly.

**Zusammenfassung.** In diesem Beitrag präsentieren wir, wie wir Multimodalität beim Design von haptischen Systemen für ältere Menschen angewendet haben. Zunächst definieren wir sechs Eigenschaften der Multimodalität: akustisch, visuell, taktil, gestikuliert, posiert und räumlich. Wir untersuchen diese Kategorien in einem Designprozess und in der Generierung der Design-Artefakte. Wir illustrieren die Interaktion mit unseren Nutzern und Nutzerinnen bzw. stellen den Fokus der Multimodalität in so einem Designprojekt auch im Zusammenhang mit verwandten Ansätzen dar. Am Schluss fassen wir unsere Ergebnisse zusammen.

**Summary.** In this paper we present how we applied and analyzed multimodality in design of tangible communication systems for elderly. First we define six categories of multimodality (aural, visual, tactile, gesture, posture, and space), which we integrate in our design processes and design artifacts. We illustrate how user interaction has been established, especially when multimodality is central to our approach. We also discuss multimodal design in context of user experiences, user-centered design, and participatory design approaches. We show the added value and change of focus through multimodality in design processes. We analyze our findings before we conclude our paper.

### 1. Introduction

Considering users' skills and perspectives in a design process has a severe impact on the approach designers choose. User experience (UX) is individual and not social. It emerges from interacting with an artifact and includes emotional, affective, experiential, hedonic, and aesthetic variables of users (Hassenzahl & Tractinsky, 2006). How can we evoke user experiences out of anticipated use? How can we establish an environment for a cooperative evaluation of UX in early phases of a design process, i.e., without having a product or system already to experience with? How can we capture methodically and systematically UX during interaction with users? This paper presents how we managed to answer these questions in a design project for elderly. We based our design on UX and multimodality. We applied multimodal design methodologies, and defined multimodality with the categories aural, visual, haptic, gesture, posture, and space. In the next section, we present our multimodal design approach. With a case we illustrate how we can apply it in projects. We discuss our findings before we conclude our paper.

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### 2. Multimodal Design

Multimodal research is an emerging young research field. Besides well-known keyboard or computer mouse, human-to-human interaction in HCI includes user input via voice, gestures, or tangible objects. Accordingly, the output of a multimodal interface addresses various senses of the user, like visual, acoustic, or tactile feedback (Reeves et al., 2004). The focus of UX, especially in product design, is on the user interaction with the product, by pushing a button, by positioning certain objects in a specific way, by meaning and interpreting sounds provided by the system to react to system's behavior, by changing the course of interaction through involving the whole body, voice, activating or deactivating certain objects available for interaction, etc. As illustrated in our case, user interactions are multimodal independently what type of devices they are interacting with. There are aural, visual, and spatial elements in interaction. Especially use of space and spatial organizations challenges design and design decisions (Patten & Ishii, 2000). Based on the technique of multimodal analysis the relevant multimodalities needed for analysis and design were de-

finied. Next to spoken language head and arm movements, body posture, etc., six categories originating from an accompanying PhD thesis (Ehrenstrasser, in progress) form our base to understand communication and interaction situations: Aural: Everything hearable like spoken words, noises, sounds, acoustic interaction feedback and guidance. Visual: Everything seeable like photos, drawings, visualizations, representations, sketches, collages, visual interaction feedback and guidance. Tactile: Everything tactile, haptic graspable and physical like shapes, materiality, material surfaces, three-dimensionality and physicality of artifacts and designed objects, collages, tactile interaction feedback and guidance. Gesture: How people work, point and move with their hands and interact with objects, artifacts, and materials. Posture: How people posture their body and use their body in relation to the interface during interaction. Space: How people make use of the space and room around an interface, configure their body positions in relation to others and surrounding artifacts. The categories are bidirectional, e.g., audio has always an impact on space and space to audio, gesture influences tactile experience and vice versa. In the next chapter,

we present our case, in which we could investigate the multisensory experience of our users in different settings.

### 3. The Case and the Prototypes

Our case is about designing innovative ICT to support communication and social interaction among elderly people. In the research project *kommTUi* (funded by FFG, No: 823577), we developed several prototypes in three iterations with users. By means of video and audio recording, we gathered data during the workshops, which we analyzed multimodal. On the one hand, we were looking for non-stigmatizing ways of interaction for elderly. On the other, we investigated whether and how ICT with tangible user interfaces are more suitable for elderly and whether haptic interaction mechanisms improve the application and acceptance of ICTs by older people. In total, we had seven stations with different prototypes. In this paper we present only three.

#### 3.1 The Board Game

We implemented a wooden board game based on Connect 4 (Figure 1).

Two players, sitting side by side, can play it having direct face-to-face communication. The game is multimodal: It can be played both by visual and tactile contact and also blindfolded (Figure 3).

We used 21 red and 21 white differently shaped figures to ensure a high visual contrast as well as a tactile distinction.



Figure 1: The Board Game.



Figure 2: Example of unified and distributed cognition.



Figure 3: Example of material interaction when played blindfolded.

At the beginning, both players do not know how to start and play the game (Figure 2). Sitting side by side they talk about their experiences with this game if any and ways of playing it. Independently of what is being talked, one player grabs a figure and scans it with her both hands. This type of approaching the game is important to get familiar with it and its figures. Spoken exchange is an example of unified cognition, whereas sensing and scanning a game figure is distributed.

Two players decide to play the game blindfolded (Figure 3). After tying a scarf around the eyes, one player fingers the board with the marks and holes (2) and its borders (1). This is an example of haptic guidance and helps orientation before starting to play. During the player on the right side puts her red figure into the hole, the other player asks whether she has already played her figure and holds a white figure with her both hands (3). When it is her term, she tries with one hand to find the right hole and she holds the figure with the other. Then she puts the figure with both hands into the hole when her left hand arrives the target (4). This sequence is repeated through the whole game. Both players talk very briefly and only to guide and clarify things. Of course, fingering the board to decide what to play next becomes more complex and prolonged when the game is progressing. Here we observed material interaction and the restrictions when visual interaction is prohibited.

The Board Game combines all six categories of multimodality: Players talk to each other to clarify the rules or the status of the game, like who is next, who wins the game, whether they play another game, etc. The arrangement of

the game board with letters and numbers and colored figures provide visual support. The status of the game can of course be observed the best visually. Orientation at the beginning and material interaction when played blindfolded are provided by tactile modality. Besides playing the figures, gesture around the board to support articulation or to show emotions is needed. This is connected to posture and space, like how players sit around the board, how and when they approach and move away, and body positions in relation to other player and to the board.

#### 3.2 The Launchpad Game

We implemented a digital version of the board game by using a MIDI controller for interaction (Figure 4). We covered all predefined function descriptions and buttons of the device. We connected the Launchpad to a computer, for both to execute the game and to use audio and video connection via Skype (Figure 5).

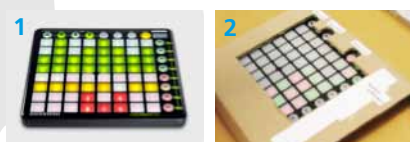


Figure 4: The Novation Launchpad device (1), the Launchpad Game (2).

Two players sitting in different rooms play the Launchpad Game. They communicate with each other through an audio- and video channel. To play a figure, the player has to press one of the LED buttons in the column.



Figure 5: Audio and video communication via Skype during gaming.

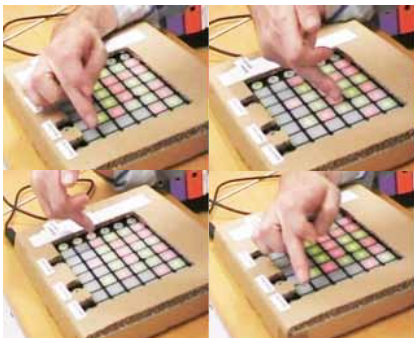
Based on the observations of different sessions played during the workshops we can illustrate some interesting user interactions. Players differ in their perception which button they should push (Figure 6): the most upper one in the column (1) or the button showing the exact position of the figure they want to play (2). Players usually look at the Launchpad dur-

ing the game. The communication with others occur in case of breakdowns or disruptions, to articulate or clarify misunderstanding of how to play the game or which button has which functionality to start a new game, cancel a game, or invite the other player to another game.



**Figure 6:** Different buttons pushed.

Sometimes players talk to themselves to think about their next move and gesticulate with their hands and fingers on the Launchpad to support their thinking loud (Figure 7).



**Figure 7:** Gesticulating - thinking loud.

There are different ways how to position and use the device (Figure 8). Some use only one hand, some both (1+2); some use the space around the Launchpad to position their hands or arms to support concentration (3); some are bored and play with their fingers on the table (4); some play with their hands while waiting (5+6); bodies are positioned differently (closer or farther to the pad) depending on the success in the game.

In comparison to the Board Game, the Launchpad Game is much complicated to understand and use in many ways: If one starts a new game, the other player is automatically invited and must confirm the invitation by pressing the "invite a friend"-button on the right side of the pad. This button starts blinking on both pads. When the invited player pushes the blinking button, the game is started. Same happens when one wants to cancel or stop a running game and start a new one. This was not always clear to

most of the players. One reason for this was the limited notification and feedback mechanism implemented on the Launchpad. Only using different colors or blinking a function button was not enough, we needed audio signals to alert situations or inform the players.



**Figure 8:** Positioning and dealing with the Launchpad.

After several tries players learned what optical signals meant and could use the pad with no delay. If the invitation was not confirmed, the system timed out after 30 sec. This happened a few times, which further confused the players because they could not understand why this happened and the blinking stopped. These observations show that visual and aural notifications are essential for interaction with a device, especially when the actions of other users must be made visible to all.

### 3.3 Sequencing Actions

The goal of this prototype was to achieve a deeper insight about possibilities and difficulties of tangible interaction based on RFID technology. Therefore, a RFID system was designed, which allows the manipulation of screen- and audio data by simply placing cards on a particular scan area (Figure 9). The system consists of a monitor with integrated speakers, an RFID reader integrated into a cardboard box (with a red rectangle at the top marking the scan area), the RFID cards (with red borders), and a standard PC for the program logic.

For the workshop, two use cases have been designed: interacting with a



**Figure 9:** Prototype for sequencing predefined actions using cards.

cat (petting and feeding the cat, the cat purrs and meows) and making tea (filling the kettle, putting it onto a stove, switching it on and off, boiling the water, pouring the boiled water). The sequence of actions for making tea is clearly defined by the application and the goal is to prepare warm water for tea. In other case, users can freely choose the order of doing things. Putting the particular start card onto the scan area starts the interactions. Each card causes a certain screen and audio output. An aural signal is used to alarm the user or give him/her a positive feedback.

This prototype focuses on space (body position in relation to interface, arrangement of cards), visual (object design, visual interaction feedback), aural (aural interaction feedback), and posture (toward interface) (Figure 9). The goal was to explore the ease of use of our tangible user interface for the elderly participants. Is the user interaction easier to learn when they can organize the interface elements (action cards) themselves? Are the interaction constraints strong enough for an effective interaction guidance of the participants?

The RFID system was located on a table, which stood in the middle of a room. We provided chairs on the long sides of the table, so the participants could choose to sit on one of the long sides of the table or just stand in front of it. The monitor was placed on the fourth side of the table, so the participants had a good line of sight to it. The RFID-reader covered in the cardboard box was mounted in front of the monitor, the RFID cards were grouped according to the use cases. It was up to the participants to use this predefined arrangement or change it according to their needs and requirements. The research question was to find out how the participants interact with this system, which they have never seen or used before and without having any information about how to use it. To sup-

port the interaction, the red rectangle on the cardboard box and on the cards were provided.

Most users positioned themselves on the right side of the table. The table was too long, the screen could not be seen easily and the scan area could not be easily used from this front end. Some of the male users changed their body position during the interaction, while female participants did not move from their original position.

One of the challenges at the beginning of the interaction was how to interact with the cardboard box and how to put the cards onto the scan area. This gives us information about the haptic interaction with the system. We could observe different ways of doing this (Figure 10): Some tried to push the scan area very hard to initiate action almost damaging it completely (1). They thought the box with the RFID reader is actually a mouse without a click button. Seeing its missing stability convinced them that pushing is the wrong way to interact with it. Some tried to wipe on the scan area (2), some to scroll like on a track pad (3). Some tried to start the interaction by using the MS Windows start button on the screen (the dock was still displayed on the bottom) by assuming it is a touch screen (4). Some tried to put two cards side by side (5) or on each other at the same time onto the scan area. Some put dependent cards in a sequence, like the cat meows and one feeds the cat (6), which unfortunately could not be read by the one port RFID reader. In all cases, the visual and aural feedback of

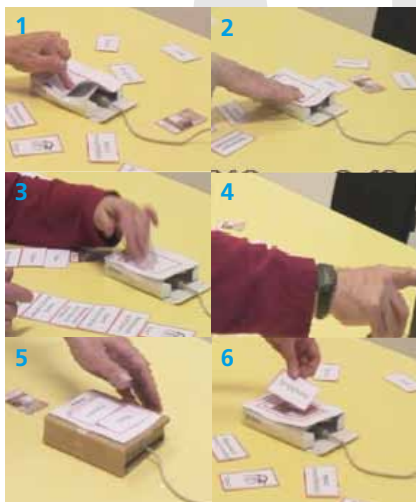


Figure 10: Different ways to interact.

the system helped users to understand and learn how to interact with the system. Due to the red rectangles almost to all it was clear in which direction and on which side they have to put the cards onto the scan area.

Users tried to sort out the cards before starting the interaction or during interacting with the system. They put them on the left or right side of the scan area in a certain order by separating the two use cases, so that they had an overview of the cards. They tried to sequence the cards on the table before interaction. Sometimes these sequences were not correct and they changed the order of the cards during interaction with the system. Though, some were confused and did not know how to proceed. Some solved the situation by starting again from the beginning. Only one user combined both use cases: first she fed the cat and then she made the tea. All others separated the use cases and did not see any connection between them.

#### 4. Discussion

In compare to known HCI approaches with audio, visual, and haptic feedback modalities, and language, gesture, and mouse as input modalities, we analyzed the differences in the body language and body posture when playing the Board Game sitting side by side and playing the Launchpad Game sitting in two different rooms. For playing the Launchpad Game, the arrangement was necessary to ensure, that the players are located on the right side of the pads and can see and hear each other. For playing the Board Game, the players were sitting in close proximity and also their bodies were aligned to each other. They could touch each other when needed, e.g., to help when played blindfolded. At the same time we studied the haptic interaction with the game figures. Playing blindfolded was possible due to the special design of the game figures: The red ones had a round shape and the white ones had a triangular shape. With this design we achieved a visual and a haptic difference.

Gaming context increased the acceptance of the elderly to communication via Skype. It was part of the game. They could ignore it and focus on the game

and use it when they wanted. It was their choice whether and when to use it.

Visual elements used in design are responsible for communication possibilities, limitations, and the state of interactions with the user. Users are informed about what they are seeing, and how it works. The design of visual elements enhanced with sound effects are in charge to transmit, on the one hand, the importance of the content and actions, and the relationships between them on the other. Sounds as ambient cues show changes in an application while users are otherwise occupied. Applications raise their voice if they need attention. Visual organization of colors, fonts, patterns, images, and visual elements shows the user how to deal with a system, how information is interrelated in the system, and what the hierarchy between interface elements is. How things are used, what material things users hold in their hands have, how users position themselves to the systems they use, how they interact with gestures to communicate with others, how the whole space is shaped and set up, become as further relevant modalities for design of systems.

When planning a workshop with older adults, it is necessary to consider the normative changes related with the aging process throughout the whole design process (Fisk et al., 2004). This is true not only for the design of different input and output modalities, but also for the workshop setup itself, e.g., wording in textual and oral descriptions, used icons, graphical guidance or arrangement of workshop rooms. As our workshops showed, considering these multimodal requirements leads to a pleasant atmosphere, which enhances the quality of the workshop results. The multimodal gaming situation described above was able to divert the elderly participants from their concerns of using new technologies. By sequencing actions, the possibility for the participants to rearrange the tangible interface elements to their own needs was very well accepted and extensively used. This helped the participants to familiarize with the interface. Beside the graphical and aural guidance, the haptic interaction with the interface elements supported the elderly participants in the initial contact with the prototype and led to easy to learn interactions.

Multimodality has impact on all types of decisions made in the process. While developing and re-designing the kommTUI prototypes, we noticed that each design decision we took implicated a high number of consequences related to other design decisions. It is not a coincidence that we could identify all categories in design settings, like the use and number of physical objects, their various materials and surfaces especially as tactile guidance and clues for usage; complex steps of interaction and chains of action; workflow and workspace organizations with the interface; the arrangement of devices, artifacts, and the use of space, etc. How we prepared our design workshops, how we carried out them, how we documented and analyzed data captured in these settings, were well designed in terms of multimodality. We argue that to design context and user aware systems all categories of multimodality are needed.

Furthermore, our users activated and deactivated the categories according to their relevance and use. Sometimes they looked at the screen; sometimes they only reacted to audio signals. We captured these changes and used them for design, even when our users were not present physically. We selected, combined, and composed these categories by analyzing the design issues they represent, before we used them in the redesign of our system. We integrated user attitudes in interaction in terms of multimodal categories into the design objects and we kept them there, like materiality and the shape of the tangible objects. So, we used multimodality as the guiding principle for our design practice.

As designers, we need approaches, process models, and guidelines to tackle all the challenges during the design of complex systems. First of all, multidisciplinary design teams are needed to facilitate multimodality in the design process. Second, the design setting must be multimodal. Besides systems we design, tools and technologies as well as room and space arrangements must be multimodal. Third, establishing a multimodal approach not only in the objects designed but also in the design process calls for user iterations and for capturing and maintaining multi-modal categories from iteration to iteration. The design must be

concerned in all phases with users, with their use contexts and use experiences, and with all potential and concrete multimodal technologies.

In our case we had processes that led us to novel interfaces. We ended in creating intelligent objects, which are configurable and haptic. We were aware of differences of multimodal categories in the process, we used them differently in our design. But we used them all.

In sum, multimodal design serves as an approach to interaction and product design of novel interfaces. Some research questions need to be investigated in the future though: Is there a specific phase in the design process where multimodal design has more impact on the design? Does multimodal design look differently in software-only projects than in hardware-based design projects, e.g., based on embedded technologies?

## 5. Conclusions

In this paper, we showed how to design systems that provide richer interaction for elderly. We showed and discussed the categories embedded in multimodal design process (aural, visual, haptic, gesture, posture, and space) not only on a conceptual level, but also we presented empirical evidence illustrating how these categories can be identified and how multimodal design can be applied in real design processes. We addressed points for improvement in design processes to achieve better, user and use aware, context sensitive, and novel technologies. Users of systems need to be a real part of the whole design process. Furthermore, users should be present throughout design, interaction, and technology decisions. Designers need to consider multimodality in the design of artifacts, in user interaction, and in the whole design process, adding to the quality of design and use.

As a future research outcome we are interested to provide more detailed design rationale and patterns to make multimodal design applicable for designers.

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