The Periscope: An Experience Design Case Study

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ABSTRACT
The Periscope is an interactive device supporting passengers in a car to explore the outside environment. Following an experience design process, we trigger positive emotions by addressing psychological needs: (a) The exploration of interesting places around the car addresses the need for stimulation. (b) When passing the Periscope on to others, discoveries can be shared and discussed, creating a feeling of relatedness among the group. We provide insights on the importance of the experience story throughout the design process and details on the interaction concept for the Periscope. Based on the story and a storyboard, we built three hardware prototypes at different early stages of the process, allowing to evaluate whether the story can be experienced during the interaction with the Periscope. Results show that early experience prototypes, implemented with regards to the story, are essential to maintain the designed experience throughout the development. With this case study, we continue the quest of introducing the car as a design space to create meaningful experiences.

Author Keywords
experience design; user experience; automotive; iterative design; psychological needs; experience prototyping; UX

ACM Classification Keywords
H.5.m. Information interfaces and presentation: Miscellaneous.

INTRODUCTION
Richard, Anna and their son Lucas have been sitting in the car for hours. The ride to their holiday resort takes forever and is standing between their busy everyday life and a vacation of fun and relaxation. Richard is driving and focused on traffic and navigation. It is not helpful that Lucas is complaining: "Mom, I am bored!"

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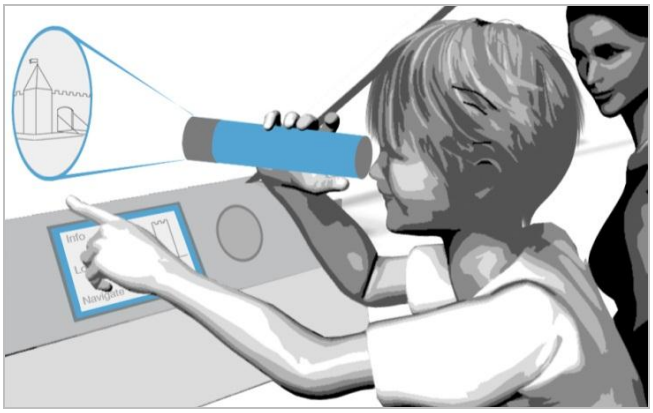

Figure 1. The Periscope was designed to explore the environment and to share discoveries with others in the car

Knobel et al. [10][11] showed that the design of passengers' interactions in modern cars is not limited to advanced driver assistant systems and driver centered infotainment equipment. Instead they built on *Experience Design* [4] and showed how cars can also be "meeting points" or "explorers' vessels" [10].

Juhlin also realized that for "participants being enclosed in the shell of a vehicle, […] driving becomes a lonely activity" and asks for "richer emotional experiences in traffic encounters" [8].

We follow their request to design for experiences [4] in the automotive domain. In this paper, we introduce the *Periscope* (see Figure 1). Referring to the metaphor of monitoring the surrounding waters from the inside of a submarine, the Periscope can be used by co-drivers to explore the outside environment and to share the discovery of interesting places with others in the car.

According to Ryan and Deci [19], our intrinsic motivation to thrive is based on psychological needs. Their satisfaction leads to well-being and positive emotions. Sheldon et al. [20] provided a list of ten psychological needs and identified the ones that are "most fundamental". In all their studies, *relatedness* and *pleasure-stimulation* have been voted among the top five, meaning that they are relevant for causing "most satisfying events" [20].

Relatedness describes the need to be close to important others and to feel intimate when spending time with them

[6][20]. Pleasure-stimulation is addressed when finding new sources for exciting sensations and activities, causing pleasure and enjoyment [20]. With the Periscope we address stimulation through exploration of the environment and relatedness by sharing discoveries.

By defining the term *Experience Design* [4], Hassenzahl established a link between the satisfaction of psychological needs and the design of interactive products. Instead of solely focusing on aesthetics and functionalities, he encourages to design for experiences that are created while interacting with the product. Thus, experience designers do not only answer the questions *what* and *how* we do something, but stress the question about *why* we do it. In our case, we want to be stimulated and close to others.

To be able to tell a story with the help of an interactive product is a major focus of experience design [4]. Thus, it is important to create a meaningful and convincing experience story, before implementing an idea through a technology. Therefore, and because they help to communicate and illustrate ideas in an understandable way [16], we start the overview of our design process with an experience story and a storyboard. Then, we introduce our concept and the interaction design of the Periscope.

With his concepts and prototypes, Juhlin [8] shows how we can benefit from emerging technology by virtually connecting traffic participants and their interests. An example is Sound Pryer [15], an integrated audio player that "tunes into other players within close proximity to hear what they are playing" [8], allowing for sharing listening experiences with others.

Following, we report on three experience prototypes of the Periscope built in early stages [2][22] of our design process. According to IDEO [1], we understand experience prototypes as interactive representations of our concepts. The effort of their implementation varied between an hour and a month, but it is important that they can be actively used and are able to communicate at least parts of the designed experience. Houde and Hill [7] defined the terms resolution (i.e. the "amount of detail" of a concept that has been realized in a prototype) and fidelity (i.e. the "closeness [of a prototype] to the eventual design"). To find out if the designed experience is communicated by the Periscope in early design and prototyping phases, we built and evaluated one low-resolution/low-fidelity, one high-resolution/mid-fidelity and one high-resolution/high-fidelity prototype.

Hassenzahl et al. [5] found a relationship between the satisfaction of psychological needs and the arousal of a positive affect. Thus, we first measured to what extend the needs for relatedness and stimulation have been addressed during the interaction with our prototypes, based on Sheldon's need questionnaire [20]. Subsequently, we measured positive affect with the PANAS [22] and PANAS-X [21] questionnaires and found a significant relationship between need fulfilment and positive emotion, showing that interacting with our prototypes triggered experiences.

Our contribution is twofold: First, with the Periscope we provide a new case study and novel device exploring experience design in the automotive context. Second, we show how prototypes can transport the story and thus the designed experience through the development process. Both case study and process influence each other: The Periscope offers us an example concept to prove the validity of our tools and in parallel the process enabled us to create an experience (i.e. the interaction with the Periscope).

In this paper, we (a) provide details on the Periscope story, storyboard, concept and prototypes; (b) give insights on our experience design process in the automotive domain concentrating on early design phases; (c) report on details of our evaluation methods using the Periscope prototypes in a car-mockup with a driving simulator and (d) draw conclusions from this design case to offer implications for similar future projects.

FROM THE IDEA TO THE PROTOTYPE

In this project, we follow two fundamental ideas: First, we tear down the barriers between the passengers inside of the car and the experience of the outside environment while driving [3][11][14]. When brainstorming this topic, a picture coming to our mind was the periscope used in submarines: the view is limited for the navigators, but the periscope allows them to see what is happening outside. We introduce this opportunity in the car and allow passengers to explore the environment and to discover interesting places that may not be seen when looking out of the window.

Secondly, we enable the sharing of a discovery made while exploring the outside environment. Passengers will literally be able to pass around what they see, which can create a feeling of closeness and belonging.

Due to the playful character of exploration and discoveries, we design for experiences based on the psychological need for stimulation. As we focus on sharing these experiences with others and on finding a destination together in a group, we aim for experiences addressing the need for relatedness.

To design an interactive device that can easily be handled and passed on, our concept and prototypes are close to a telescope. But to bear in mind the origins and metaphor of our story, we named this project Periscope. Based on this motivation and the metaphor, we scribbled first ideas, formulated an experience story [4][16] and created a storyboard (see Figure 2). These steps helped to form a clear image of the experience we design, following Hassenzahl's approach of "experience *before* products" [4].

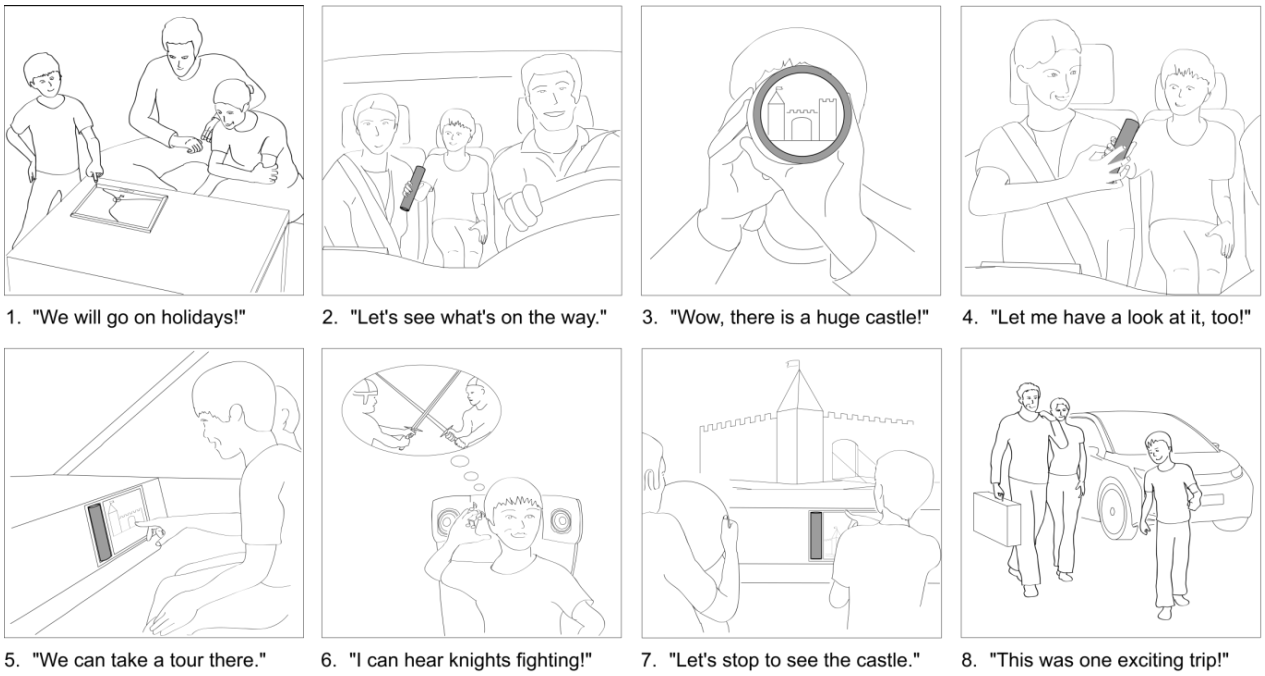

Figure 2. The key frames of the storyboard illustrate the most important moments described in the Periscope experience story

The Experience Story

One evening, Richard is sitting at the living room table with his wife Anna and his son Lucas, planning their vacation. Last year the long ride to their holiday destination was awfully boring for Lucas. This year, everything is supposed to be better. „We will really go on holidays together", Anna says. "Lucas, while we are driving, you can help me to find places we would like to visit."

During the trip Lucas is curious, what there is to see along the way. Using the periscope he is able to take a look at the sights ahead. He discovers a castle close to them, which he absolutely wants to see. Lucas is a big fan of the middle age and brave knights.

Eager to share his discovery, he tells his parents about the castle. „Let me have a look at it, too", Anna says. While taking turns looking through the periscope, they talk about the castle and who might have lived there hundreds of years ago.

"Wow, it is huge!" Lucas exclaims. He really likes to visit the castle. Anna browses through more information on the display in the car and spots that they offer tours. They can already hear two knights fighting with their swords. This trip is a real adventure for Lucas, who is happy to spend some fun time with his parents.

Throughout the design process, this story served as a crucial medium to communicate our ideas [16] to the team and people outside of the project to constantly gain feedback. More importantly, it provided us a reference point when we made design decisions and built prototypes. For writing experience stories we suggest the following aspects:

- Keep it short but coherent to communicate your ideas.
- Use a vivid language and include emotions and feelings (e.g. curious, eager, happy) to highlight the experience.
- Avoid implementation details but focus on the essential moments of the interaction.
- Finalize it before you proceed. The story will be a reference point for all further steps and should not be changed to ensure a coherent experience.

The Storyboard

Based on the story, the storyboard (see Figure 2) helps to visualize the experience and provides first details on the interactive system. The following aspects proved to be effective:

- Draw 6 to 8 key frames showing the important aspects derived from the story.
- Introduce the context and characters in the first frame.
- Show the important interactions (see frames 2, 5 and 6).
- Depict the situations that are crucial for the experience (see frames 3, 4 and 7).
- Show the positive effect of the experience in the last frame.

Concept

From writing the story and drawing the storyboard (see Figure 2) we derived the interaction concept for the Periscope: One of the passengers takes the telescope-shaped device (see frame 2) and directs it towards the outside of the car (3). When looking into it, the outside environment and points of interest (POI) will be visible through the Periscope: *"He is able to see sights ahead."*

We intentionally aim at a dedicated device instead of an app for smartphones or in-car displays. With two or more passengers in the car, as illustrated in the story, this implies an exceptional situation: Only one person can use the Periscope (2) and while talking about her discoveries (3), the others are isolated to a certain degree. This opposes the need for relatedness, but evokes curiosity and communication (4): *"Let me have a look at it, too!"*

This tension resolves as the active passenger hands over the Periscope (4) and an experience is shared between the two. An exchange about the discoveries is now possible: *"They talk about the castle and who might have lived there."* Obviously, the driver cannot use the Periscope while driving, but is integrated in the discussion about a stopover or new destination (5).

Whenever the Periscope is directed at a POI, the front-seat passenger can trigger the presentation of more detailed information in the car (5), now visible to all passengers: *"Anna spots that they offer tours."* This information can be augmented with audio information (6): *"They can already hear two knights fighting"* As soon as the group comes to a decision, the new destination can be forwarded to the navigation system (7). The important elements of the interaction are the following:

- The periscope is a dedicated device (2). In contrast, an app for the central information display rather directs the attention to the screen, not to the outside environment [11]. With the Periscope being a physical artifact [7], it can be tangibly used to explore and can be handed over (4). The use of a smartphone or tablet contradicts the story by making screen contents available to all passengers at once. Furthermore, such a device does not belong to the car but to one of the passengers, which would eventually restrict the designed sharing experience due to privacy reasons.
- We intensify the relatedness experience by isolating the person not using the Periscope (3) before it is handed over (4).
- We involve all passengers in the exploration of the environment and a decision for the next destination in a stimulating way (5).

Iterative Prototyping

In an iterative process, we built several prototypes. We kept prototyping phases short in the beginning to get quick results and increased resolution and fidelity [7] over time [2].

As first step we will introduce a preliminary prototype that was not fully functional, but an artifact [7] that we used to explore the design space and to detail the interaction concept. Then, we introduce two experience prototypes and two corresponding user studies and report insights on the process and experiences with the Periscope.

Preliminary Prototype

We implemented the first semi functional low-fidelity and low-resolution prototype within one day, realizing only a few features described in the concept. It was our purpose to get a first look-and-feel and to communicate the concept to all team members in order to receive early feedback.

We bought a toy telescope and removed all insides. Instead, we placed a small 0.96″ TFT display that was controlled by an Arduino microcontroller at the far end of the telescope. We placed some random pictures of buildings on a SD card, which were displayed on the screen as a slide show. Besides looking at the images through the telescope, no interactions were possible.

During a two-hour workshop with five team members and five participants unfamiliar with our work, we introduced our story and storyboard. Then, asked them to imagine themselves in the scenario and to share thoughts and ideas while using the telescope. During the session, we took notes and observed how people interacted with the telescope, passed it around, discussed the content of the images and came up with ideas about the handling and possible applications of the prototype. While clustering and discussing the qualitative feedback from the workshop, we added details to the Periscope concept concerning interaction with and implementation of the next prototype.

- At first contact, people raised concerns over the actual telescope we used for prototyping, describing it as "cute" and "immature". While using it, their impressions changed in a positive way: "Everyone knows how to use a telescope" and "it invites to explore the prototype and the images shown".
- In the beginning, users will see a large-scale representation of the surrounding area. When turning around, the visible part of the environment will change depending on the direction the Periscope is pointed at. A zoom wheel known from camera lenses allows for the exploration of interesting regions.
- After spotting a POI and zooming in, the Periscope will show the name and a picture. When zooming out, this extra information will fade out.
- The Periscope will have a button to 'freeze' the screen and point-of-interest (POI) currently visible. Thus, it can be handed over without losing the image that is going to be shared.

Concluding, the early prototype helped us to gain first insights concerning the overall functionality and interaction with the Periscope as well as the general understanding of the metaphor.

FIRST EXPERIENCE PROTOTYPE

Based on the hands-on experiences with the early prototype, we refined the storyboard and updated our concept. We implemented a more sophisticated mid-fidelity and high-resolution prototype (see Figure 3) within one

week. The goal was to communicate all features described in the concept with a prototype that can be built with relatively low effort in a short time, but that is robust enough to be used in a first user study.

Hardware

The centerpiece of the first functional Periscope is a smartphone based on Android. We use sensor data from the internal Accelerometer to track up/down and left/right movements of the prototype. In the screen area visible when looking through the Periscope, we display a representation of the outside environment. An acrylic glass housing made with a laser cutter holds the smartphone in place. Users can press a button located on the top side to freeze the contents before passing the Periscope on to another person. The tail end of the tube is rotatable and connected to a variable resistor, implementing the zoom functionality of the Periscope. We added an Arduino Micro board and connected the button and the variable resistor, all being housed inside the tube.

Figure 3. Participants using the first functional Periscope

Communication & Software

We implemented a Java server to analyze input (movement, zoom and freeze) and to generate output (shown on the smartphone). The server runs on a dedicated computer and creates a TCP connection to the smartphone via WiFi. The Arduino is connected to the server, powered by the USB port of the computer and transmitting sensor data from the button and the variable resistor.

A smartphone application shows a pre-defined high-resolution panorama image. Being a prototype, the image is a fixed representation of the outside environment and is not updated while using the Periscope. The screen area visible while looking through the Periscope shows a clipped part of the image depending on the zoom level and the direction the Periscope is facing. POIs are presented on the map as small red markers. When zooming into a POI, a picture of the building or place appears.

We placed a 7″ tablet computer on the dashboard of a car-mockup directly in front of the co-driver. The tablet communicates with the server via USB. Whenever a user touches the screen after zooming into a POI, we provide additional information such as pictures, opening hours and audio guide-like feedback.

First User Study

With this initial functional prototype, we conducted a first user study (see Figure 3). We focused on the question if the interaction with the Prototype will lead to a feeling of (a) relatedness, (b) stimulation and if this overall leads to (c) positive emotions. We also collected qualitative feedback for a revision of the concept and to inform the design of a new prototype. Note that this evaluation was conducted in an early design stage. Thus, we did not intend to test usability or driver distraction but rather the ability of the Periscope to communicate the story and to trigger a positive experience before building high-end prototypes.

Setup and Procedure

A total of n=28 participants with a mean age of M=25 (SD=6) attended our study, nine of them female. Because our story describes at least a front-seat and a rear-seat passenger using the Periscope, we recruited two attendants per session, resulting in 14 groups. As an incentive, we handed a 10 Euro gift certificate to each participant. At the beginning of the experiment, we presented the storyboard to immerse the team in the following situation:

You are leaving town for a leisure ride in your car. You have no idea what to see on the way. With the help of the Periscope, you can discover interesting sights. Please do so and decide together, where you would like to go. You have as much time as you need.

Then, we seated both participants in our car-mockup and explained the prototype's functionality. The mockup (see Figure 6) consists of a chassis, front and back seats, front doors, windshield, steering wheel as well as acceleration and brake pedals. To focus on the prototype, we decided against a driving simulation, but the mockup conveys a feeling of sitting in a car.

Method

We measured the fulfillment of both psychological needs, stimulation and relatedness, with a scale [12][13] based on Sheldon [20] consisting of three Likert-like items each that range from 1 (do not agree at all) to 5 (completely agree). To determine if the interaction with the Periscope was enjoyable, we used a short version of the Positive Affect Negative Affect Scale (PANAS) [9][22]. This questionnaire measures positive affect (high energy, pleasurable engagement; PA) and negative affect (distress, unpleasurable engagement; NA) by means of five Likert-like items ranging from 1 (not at all) to 5 (extremely). Then, we interrelated both questionnaires to find out if positive emotions were actually triggered by fulfilled needs.

After the experimental session, we interviewed participants. Questions were "What did you like about the Periscope?", "What would you improve?" and "What was confusing about the prototype or the interaction?" We recorded if the team signed up for the study together or if both did not know each other before.

Results

The psychological need for relatedness was rated above the scale mean of 3 (M = 3.55, SD = 0.81). Stimulation was rated high (M = 4.07, SD = 0.56). Participants rated the positive affect in the interaction as moderate (M = 3.37, SD = 0.72), a negative effect did not occur according to the rating (M = 1.27, SD = 0.27). The scales showed an acceptable (stimulation: α = .63; relatedness: α = .69) or good (PA: α = .77) reliability expressed in Cronbach's alpha, reporting the internal consistency of a scale.

We found a significant relationship between positive affect and relatedness (r = .41, p = .03) and stimulation (r = .44, p = .02), but no significant relationship to the negative affect (relatedness: r = -.15, p = .46; stimulation: r = -.21; p = .29).

If both team members knew each other before the experiment, the feeling of relatedness was rated higher ($t(26)$ = -2.30, p = .03) with $M_{familiar}$ = 3.77 over $M_{unfamiliar}$ = 3.04. Results of multiple independent t-tests show no significant differences of the experience between the front seat and the back seat passenger (relatedness: $t(26)$ = -0.38, p = .71; stimulation: $t(25)$ = -0.20, p = .84; PA: $t(26)$ = -0.84, p = .41; NA: $t(26)$ = -1.14, p = .27).

Discussion

Qualitative Feedback: Relatedness and stimulation have been affected through the interaction with the Periscope, leading to solely positive emotions for both passengers. Interview statements support this result, such as "I liked the social event: We explored the environment in an exciting and playful way" or "with the Periscope we can relieve our boredom on long drives" (all statements have been translated by the authors). Especially the moment of passing the Periscope on was commented positively: "I can explore something and give the frozen image to [the person] in the back. It's a way to share my experiences."

Need Questionnaire: Relatedness was rated only slightly above the scale mean. This indicates a moderate fulfillment. As one reason, we assume the items covering rather strong relationships, e.g. "I was close to people who are important to me." Although participants acted as a team, they were not necessarily close to each other. Participants who signed up for the study together rated items significantly higher, supporting this assumption.

Usability: Concerning the prototype, eleven teams found it "easy to use". However, we earned criticism concerning the handling, leading to a list of issues we addressed with the next prototype: "At first, I didn't know which way I need to hold it" and "it is kind of clumsy and I got tangled up in the power cord". A 53 year old was not able to focus on the screen and held the Periscope farther away from him, making it harder to see details. Several users reported jitter in the picture seen through the Periscope.

We conclude that the early mid-fidelity prototype was feasible to communicate the experience story, which was 'relived' by participants. Quantitative and qualitative results allowed us to go to the next iteration in our experience design process.

SECOND EXPERIENCE PROTOTYPE

We spent significantly more time and effort for this update, resulting in a high-resolution and high-fidelity prototype (see Figure 4). We improved the following design and usability issues according to study results to also improve the experience.

- The Periscope is a stand-alone and wireless device, improving handling and flexibility.
- The prototype has the look and feel of a telescope, less clumsy compared to the previous one.
- Tracking of movements is more precise leading to a smoother update of the screen inside the Periscope.
- Due to the close-up lens, the visibility of the screen-contents is improved, addressing farsightedness.
- We integrated the Periscope into the car by adapting its color and embedding it into the dashboard.
- The application on the display stores discovered POIs, additional information can now be retrieved at any time.

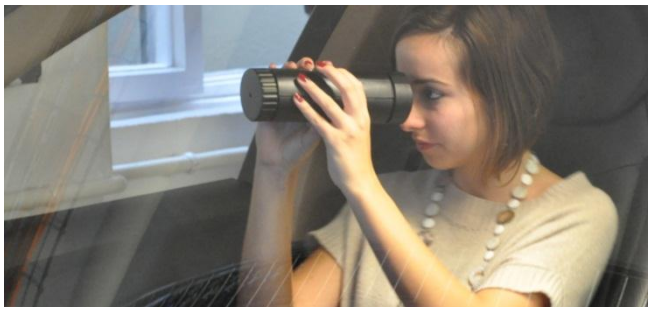

Figure 4. The second Periscope experience prototype

Hardware

In contrast to the first prototype, we embedded all hardware into the telescope-like housing (see Figure 5). A Motoactv smartwatch replaced the smartphone screen. To track the orientation of the Periscope, we used a Pololu MinIMU-9 v2 inertial measurement unit (IMU) including accelerometer and gyroscope. To read and process sensor data, we added an Arduino Pro Mini. To send data from IMU to Motoactv, a LiPoly USB shield was necessary. As in the previous prototype, a button realizes the image freeze and an incremental encoder tracks the zoom wheel rotation.

To realize a stand-alone device, we included two rechargeable battery packs with voltage converters and chargers, powering Arduino, USB shield and IMU for several hours. Thus, the Periscope is a wireless device.

To fit the hardware and all wires, we built a custom-made housing. According to the hardware setup and the dimensions of the parts, we created an accurate 3D model using CAD and materialized the housing on a 3D printer.

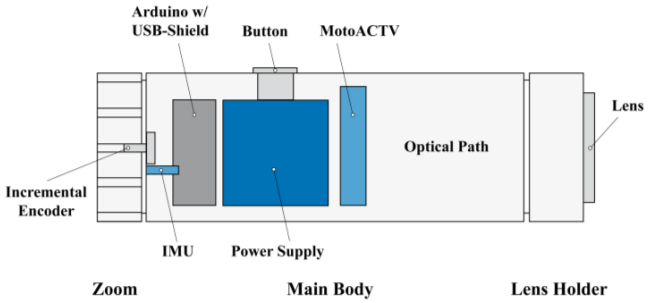

Figure 5. Schematic of the second Periscope prototype

The top of the main body can be removed for charging and maintenance. Because the zoom wheel needs to be rotatable, it is an extra part attached to the encoder. The last part of the Periscope holds an optical lens. According to observations with previous prototypes, elderly users had problems to focus on the image due to a short distance between screen and eye. To address the problem of presbyopia, or farsightedness, we use a 10-diopter lens.

Communication & Software

According to the previous version, a Java server takes care of the communication between the Periscope and the co-driver display on the dashboard of our car-mockup. While looking through the Periscope and pointing it in different directions, the sensors on the IMU track these motions. The Arduino reads the data and maps it to a position on a virtual map. Additionally, it converts data from the encoder to a zoom value and determines if the button is pressed to freeze the current position of the Periscope. Using the Android Development Bridge (ADB) via USB, the Arduino communicates the data to the Motoactv. The Android application running on the smartwatch updates the visible area of the high-resolution image representing the outside environment and updates the screen accordingly. The Java server reads the point of interest currently selected and whenever the display in the car is activated, it shows additional information and audio feedback.

Second User Study

Similar to the evaluation of the previous prototype, we conducted a second study to investigate the fulfillment of the psychological needs for relatedness and stimulation and the arousal of positive emotions while interacting with the updated Periscope. Due to the considerably higher investments in terms of time, costs and effort, we expected an improved user experience and a more enjoyable interaction compared to the first study.

To match the experimental situation closer to the story and the storyboard, each group was set up with three members, adding a driver to the front-seat and rear-seat passenger. The driver takes a special role, because he can follow the conversations and actions triggered by the Periscope, but he is not able to participate in the interaction with the prototype. Therefore, we were interested in his user experience and potential social implications.

Setup

We did not change the setting for this study and used the same car mock-up (see Figure 6). However, due to the inclusion of the driver, we added a driving simulator to the setup. The driver was able to use steering wheel, acceleration and brake pedal to steer the vehicle on a virtual country road. We projected the simulation on the wall in front of the car mock-up and displayed information on the current speed and the speed limit.

We evaluated the third Periscope prototype with 13 groups, resulting in 39 participants, twelve of them female, with a mean age of M = 24 years (SD = 3). In parallel to the previous study, we introduced the same storyboard and asked the teams to assume the same scenario. We seated the team according to their preferences with the only requirement for the driver to have a valid driver's license. While he or she got used to the driving simulator, we demonstrated the functionality of the Periscope to the passengers. We requested the driver to primarily concentrate on the driving task but allowed him to take part in any conversations, according to real driving situations. Again, we told the team to take as much time as needed to explore the possible interesting sights with the prototype and to agree on one destination to end the session.

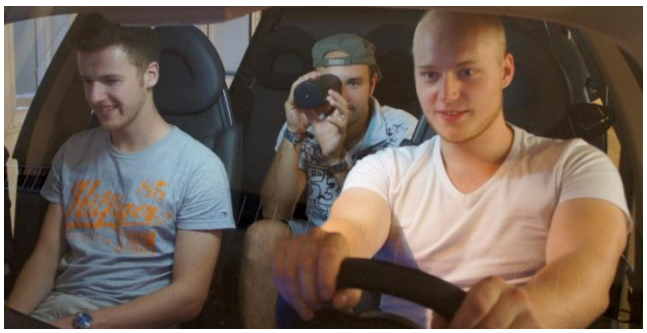

Figure 6. Participants using the second Periscope prototype

Method

To measure the fulfillment of both, relatedness and stimulation, we used Likert-items [12][13] based on Sheldon [20]. To address the issue of the items used in the first study aiming at rather close relationships between the team members, we used five instead of three items for this study, e.g. adding "I felt as part of a team". To determine how enjoyable the interaction is rated, we included the joviality scale of the PANAS-X [17][21] in our questionnaire. With the PANAS-X, Watson and Clark divided their original PANAS [22] questionnaire up into different subcategories.

In addition to the questionnaires that each participant received after the experimental session, we interviewed the teams using laddering [18], an interview technique revealing the underlying values and psychological needs behind favored attributes of a product by repeatedly asking questions about statements by a user.

Results

The duration of the driving sessions were between 10 and 15 minutes. The psychological need stimulation (see Table 1) was rated as rather fulfilled ($M = 3.97$, $SD = 0.68$), the need relatedness was seen as moderately fulfilled ($M = 3.48$, $SD = 0.83$). The interaction was seen as moderately jovial ($M = 3.34$, $SD = 0.58$). All scales showed a good reliability (stimulation: $\alpha = .84$; relatedness: $\alpha = .78$; joviality: $\alpha = .83$).

	1st Prototype		2nd Prototype	
	M	*SD*	*M*	*SD*
Relatedness	3.55	0.81	3.48	0.83
Stimulation	4.07	0.56	3.97	0.68
Positive Affect	3.37	0.72	3.34	0.58

Table 1. Comparison of the descriptive values for psychological needs and positive affect

A one-way ANOVA did not find significantly different ratings by all three roles for the fulfillment of the psychological needs and the joviality (relatedness: $F(2,33) = 0.26$, $p = .77$; stimulation: $F(2,36) = 2.47$, $p = .10$ and joviality: $F(2,36) = 1.04$, $p = .36$). As a side note, drivers rated relatedness highest ($M = 3.66$, $SD = 0.89$) and stimulation lowest ($M = 3.65$, $SD = 0.86$).

We conducted a linear regression (dependent variable: joviality, $R^2 = .37$, Method = Enter) to see if both needs are significant predictors of the joviality in the interaction. Both of the needs are in a significant and unique relationship with the joviality (see Table 2). The partial correlation (controlled for joviality) between stimulation and relatedness was not significant ($r = .16$, $p = .36$), thus the two scales can be seen as independent.

Need	B	Standardized β	*t*	*SE*
Relatedness	0.25	.38	2.48	0.10
Stimulation	0.30	.33	2.18	0.14

Table 2. Linear Regression shows that Relatedness and Stimulation predict Joviality ($R^2 = .34$, Method: Enter)

When using laddering during interviews, 20 participants stated aspects they liked most that relate to stimulation. We allocated statements of 12 participants to the need for relatedness.

Discussion

Results show that the interaction with the updated Periscope addressed both psychological needs, leading to positive emotions in terms of joviality. Statements during team interviews supported this feeling of stimulation ("when you don't know the area, it is great how you can explore it with the Periscope" or "I was happy to have something to do during the ride") and relatedness ("usually I feel excluded on the back seat, but with the Periscope I was in contact to the people in front" or "I was able to share what I discovered with the others").

An anecdotal evidence for the stimulating character of the Periscope: When one co-driver laughed out loud at something he just discovered, the rear-seat passenger instantly looked in the direction the Periscope was pointing, just to notice that all he could see was the wall of our research lab, causing him to smile.

Interestingly, qualitative and quantitative results show positive experiences for all three roles. We expected this for front-seat and rear-seat passengers, but here we were particularly interested in the drivers. Even though they were curious about the Periscope, they stated that it was ok to be left out of the actual interaction with the prototype. They felt "included in the exploration and the discussion about the favorite destination" and "informed because of the audio feedback". One driver was "happy that the co-drivers had the job to look for interesting things to see" and that he was able to "concentrate on driving without feeling left out". This indicates that the driver was part of the experience, even though the focus of the story was on the other passengers in the car.

We conclude that participants relived the story by interacting with this advanced prototype despite a number of significant changes of hard- and software. This shows that the experience we designed for was not lost due to the development of the prototypes.

DISCUSSION

To provide insights into our experience design process, we discuss results from all stages including story, storyboard and interaction concept, the preliminary prototype, as well as both consecutive experience prototypes with their corresponding user studies.

The experience story together with the storyboard constitutes the starting point [4] of the design process. It was written with a strong emphasis on the desired experiences and emotions. When running into important decisions regarding the implementation of the Periscope, it was our first priority to follow the story with the goal to create an unambiguous experience. One example is the choice of realizing a physical device instead of a software app. Especially the element of the story, which described the moment of physically sharing the Periscope, and the focus on the outside environment was of utmost importance to generate feelings of relatedness and stimulation and let us stick to a dedicated device.

The interaction concept emerged directly from the experience story and the storyboard. Please note that we allowed for changes of the concept in the course of the design process, but only if this did not contradict the story. The first draft of the concept was purposely not a detailed description of a first implementation. Instead, it focused on the sequence of interactions and resulting experiences by individuals and the group, such as the isolation of one person while the other explores the environment.

An early prototype was inspired by story, storyboard and interaction concept. Based on essential feedback during a workshop, we added details to the concept describing handling and appearance of the Periscope in a more sophisticated way. For instance, we added features like a wheel for zooming into POIs and a button to 'freeze' a discovery before sharing it.

The first functional experience prototype was built within a week and did not focus on usability and aesthetic, resulting in a mid-fidelity, clumsy and premature device. However, it realized the concept and enabled participants to relive the story. Using the Periscope proved to be an experience addressing the needs for relatedness and stimulation, leading to positive emotions.

The second experience prototype implemented a high-fidelity device built within a month, realizing feedback on usability and functionality of the previous Periscope. A new evaluation showed that our story is still communicated when interacting with the Periscope. Qualitative feedback on design and handling was more positive compared to the previous version. Despite the significantly higher investments of time and costs, the satisfaction of both needs and resulting positive emotions were not rated higher compared to the mid-fidelity prototype (see Table 1).

Fast interactive prototypes, which are focused on the communication of the experience story, can create positive experiences. With this in mind, early and iterative prototyping is suitable to conduct evaluations at all stages of the experience design process, especially before spending time, effort and money to implement sophisticated representations of a future system.

Several experience evaluations on the way from low-fidelity to high-fidelity experience prototypes are an essential indicator whether the story can be relived during the interaction. However, results from the first study did not only influence prototyping, but also the setup of the experience evaluation itself. For instance, we added items to the need questionnaire to address more aspects defining these needs, such as feeling part of a group in addition to feeling close to important people. We are aware that this influences the comparability of the two studies. Nevertheless, evaluations about how well prototypes communicate the story are essential early steps in our process. Most importantly, they helped us to show that the experience we designed for was not lost due to technological constraints or other influencing aspects.

The different roles of driver, front- and rear-seat passenger reported similar experiences, only distinctive by qualitative statements. All felt part of the group, supporting the relatedness experience of the Periscope. Note that the driver also experienced relatedness and stimulation, even though he was not using the Periscope directly, being positive side effect of this case study. However, it shows that an experience story must consider to all individuals involved to avoid unexpected experiences.

FUTURE WORK

So far, our first prototypes have been evaluated in a driving simulator in early design stages, concentrating on the 'experienceability' of the Periscope. As a next step, we plan to transfer experiences we made during our process to real driving situations and to further include usability issues into the evaluation. We are especially curious to compare study results with those we collected in the lab. Moreover, it will be interesting to introduce the Periscope to different user groups [14] such as families, friends or business partners and to explore differences between the experiences. The novelty effect of the Periscope might have had an influence on pleasure-stimulation. Long-term studies using the Periscope during several trips are needed. As we indicated with the adaptation of our evaluation setup, methods to quantify experiences need to be improved and possibly adapted to match a certain context such as the automotive domain. As a starting point, case studies like this provide valuable insights.

CONCLUSION

We introduced the Periscope, a device to explore the environment and to share discoveries with other passengers in the car. With story and storyboard as starting point in our experience design process, we created experiences based on psychological needs for relatedness and pleasure-stimulation. Always focusing on the story, we iteratively built several hardware artifacts, increasing resolution and fidelity with each prototype. We evaluated two fully functional but unequally mature prototypes regarding the arousal of experiences and positive emotions. The experiences we made during this project lead us to the following implications:

- The story is a central element in the experience design process and a fixed reference point for design decisions, ensuring unambiguous experiences. Avoid implementation details and keep it short but coherent. Use vivid language, describe feelings and emotions, and focus on the important interactions.
- The storyboard visualizes and details the story. 6-8 frames depict setting, characters, the most relevant moments and interactions and the positive effect of the designed experience.
- A concept, focusing on situations and interactions important for the intended experience, translates the story into interactive prototypes. Early non-functional prototypes detail the concept.
- Early functional but premature prototypes are suitable to evaluate whether the story is communicated during the interaction and if desired experiences are created. In early design stages, these evaluations are feasible to be conducted in a simulator environment, aiming at low costs, agile development due to fast results and a safe testing environment.

- An enhancement of the prototype's usability does not necessarily lead to greater satisfaction of psychological needs, supporting the importance of early and fast prototypes.
- To avoid unexpected experiences and side effects, all persons involved in an interaction should be considered in the story.

With the Periscope, we contributed a new experience design case study. We set a focus on experience prototyping in early design phases, implementing the important elements of the underlying experience story. With our results, we hope to encourage experience designers to include interactive prototypes in early stages of the experience design process and to further explore the car as a design space for different kinds of positive experiences.

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