BreathScreen – Design and Evaluation of an Ephemeral UI

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ABSTRACT
We present BreathScreen, a concept where clouds created by breathing are used as a projection surface for a picoprojector, creating an ephemeral user interface. In cold weather conditions the clouds are created naturally by warm breath condensing, but in other conditions an electric vaporizer may be used. We present an initial evaluation of the concept in a user study (n = 8), utilising a vaporizer-based BreathScreen prototype. The concept was positively received by study participants as a natural, hands-free interface and considered magical and aesthetically beautiful. Additionally, we provide guidance on the quantity of content that may be displayed on a BreathScreen, which is limited both by the length of a human breath and the contrast of the system.

Author Keywords
Evanescent screen; fog screen; ephemeral user interfaces; picoprojector.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Today, different kinds of enabling technologies allow us to create solutions for interaction which have particular design drivers such as delight or unobtrusiveness or to target particular usage contexts. Materiality in interactions has been recognized to have great potential both in utilitarian and aesthetical aspects in creating interactive systems [33]. Also, different technologies can be used to promote the human ability to grasp and control physical objects and materials, as Hiroshii Ishi has highlighted [13].

Ephemeral, i.e. short-lasting, user interfaces are an interesting area for interaction design [7]. The benefits of ephemeral UIs have been argued to lie, e.g., in the aesthetics of the installation, and in their ability for temporal information presentation [6, 31], which cease to overload the user. This is especially relevant as we are increasingly surrounded by different types of information displays, to the extent of creating 'display blindness' [19]. Ephemeral UIs can be deployed using materials, such as soap bubbles [8] or ice [32], which by their very nature vanish over time. However, research on ephemeral UIs is, so far, still scarce and the proposed designs have mainly been introduced as concepts or proof-of-concept level demos, without rigid evaluation.

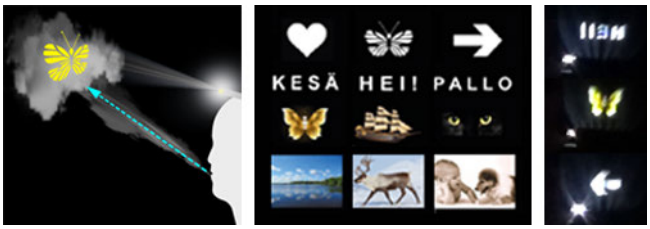

Figure 1. BreathScreen concept (left), Task 1 images (middle) and photos taken during the Task 1 user study session (right).

In this paper, we describe an ephemeral UI, BreathScreen, which is created from the air the user exhales, and when combined with frost or smoke creates a background to which a pico-projector is directed (Figure 1). As a contribution, we describe the BreathScreen concept and prototype, and present the first user study on a breath-created fog screen UI.

RELATED WORK

Ephemeral User Interfaces
Ephemeral UIs typically include elements that are intentionally designed to last for a limited time [7]. Earlier examples include a touch screen made of ice [32], soap bubbles as part of an interactive system [26], and a pervasive display created by candlelight [12]. From the durability point of view [7], an ultrashort durability ephemeral UI lasts only a few seconds, and thus encompasses materials such as fog and smoke. A commercial example of a UI using fog as projection surface is Fogscreen [9].

Temporality and ephemerality as design drivers have recently gained a growing amount of attention in design research and human-computer interaction (HCI) fields [5, 7, 13, 26, 30]. Also, industry has started to deploy temporal and ephemeral features such as disappearing and self-destructive messages [28, 35]. From the experience and aesthetic point of view it has been noted that natural ephemeral UIs can offer naturally exclusive, multi-sensual experiences and create strong emotional responses [30, 6].

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Around-the-Body Public Displays

Using the space around the body for displaying information has been researched especially with projected content [36]. In the area of personal projection, numerous use cases with a personal picoprojector are illustrated in the SixthSense concept [18] and by Winkler et al. [34], who utilize the ground around the user as a display area. Also, interaction with mid-air wearable displays and a body attached rigid display has been studied [4]. Displays in the air have also been demonstrated by using flying or hovering displays e.g., a flying display attached to a drone [24]. The use of water drops in displays have been widely studied e.g. [3, 22]. Especially relevant for our work is SensaBubble [26], where information is projected on smoke contained within a soap bubble floating in the air. These examples however do not operate in a body-centric space. In contrast, wearable body-attached displays typically do not utilize the surrounding space [11, 17, 25].

Positioning and Contribution of Our Work

Our work is positioned at the cross-section of ephemeral displays and around-the-body displays, and has novelty in proposing and evaluating a new concept in this area. We present a study exploring the serendipitous and ephemeral information presentation with a breathable fog display, BreathScreen, and chart both experiential and performance factors related to interaction. Prior art has demonstrated blowing air as an input method, used e.g. as game a control [20, 29], in amusement rides [16], and as an interaction method for the disabled [9, 23]. However, these concepts do not link with ephemeral output mechanisms and do not aim for experiential information presentation. This paper presents the first user study of a breathable fog screen, and hence extends the concept description presented in [2].

CONCEPT AND PROTOTYPE

The BreathScreen is created in front of the user's face by exhaling in a cold environment and projecting information on to the momentarily appearing fog cloud (Figure 1). To evaluate the concept in controllable conditions, we constructed a prototype of a human-driven evanescent screen, BreathScreen (Figure 2), consisting of a disposable plastic blowing tube with an inner diameter 10 mm, a vaporizer such as used in electronic cigarettes, a DLP picoprojector (MobileCinema i55) which provided 50 ANSI lumen of brightness [1], and a 3D printed assembly on which the components were mounted.

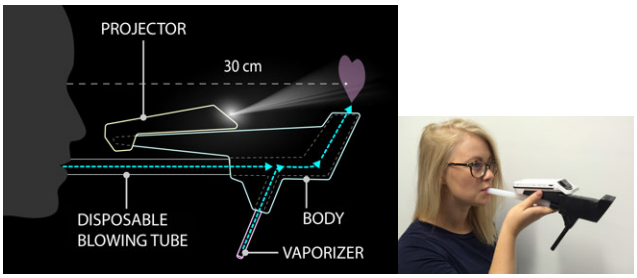

Figure 2. BreathScreen prototype.

The vaporizer was positioned such that the airflow from the user's mouth drew air through the vaporizer, creating a fog screen approximately 30 cm from the user's eyes.

USER STUDY SET-UP

With our user study, we sought to gain insight into four main themes: 1) the overall experience with BreathScreen, 2) the visibility of the visual content, 3) the optimal character size for textual information presentation, and 4) the relation between quantity of content and visibility time. The study process was as follows:

- Background information and consent forms
- Measuring the user´s Pinnacle Peak Flow value (PEF)
- Conducting Tasks 1-3 with the BreathScreen prototype
- Semi-structured interview
- Small gift (candy) given for participation

Task 1 focused on *first impressions and different content types*, including 12 different kinds of image (symbols, 4 or 5 character texts, color images and photos), which the participant materialized with the BreathScreen (Figure 1). Participants were asked to think aloud their first impressions and perceptions during the task procedure.

Task 2 addressed the *character size in information presentation*. The task included two test conditions, projection on a fog screen and, to gain a baseline, on a solid surface. The solid projection surface was positioned at an identical distance of 30 cm from the user's eyes. The presentation order of the conditions was alternated between participants. In each condition, bolded capital letters in the Calibri font at 9 different font sizes were presented in random order to the test participant, who was asked to recognize them (Table 1). The character shown at each font size was randomly selected from the set. The presentation order of the different font sizes was randomized. Correct answers and blowing times were recorded.

Used characters	N,V	Y,O	H	I, L	M,K	S,T	U,A	D,E	H,B
Font size	25	50	75	100	125	150	175	200	225
Size on fog (mm)	2	4	6	7	9	11	13	14	16

Table 1. Used characters, sizes and rendered sizes on the fog screen on Task 2

Task 3 considered the *quantity of content* to determine how much information content the BreathScreen can support. A 3x4 grid of symbols was used, consisting of squares and between 1 and 8 triangles (Figure 3).

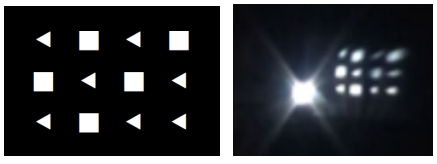

Figure 3. Example task 3 image (left) and when rendered on the blown fog screen (right)

As test content, 15 images were created with the amount and location of the triangles was altered. Participants were

asked to count the number of triangles, and the time and number of breaths required was recorded. To establish a baseline, participants repeated the task with the images projected on a solid wall at the same size as when rendered on the BreathScreen. The size of both screens was 5.5 x 7.5 cm, and did not vary during the tests. At the end of the tests a semi-structured interview focused on the following themes; impressions and experiences of using blowing as part of the UI, potential use contexts for short-lived information presentation, benefits and challenges of the BreathScreen approach, willingness to use, issues related to acceptance of BreathScreen, and future development ideas.

The evaluation was conducted with eight participants (3 male, 5 female), aged 27-65 years (M = 43, SD = 17.2). All participants had normal corrected vision (5 with glasses, one reporting astigmatism). In order to verify the participants' capability to blow, we measured their PEF values, and compared the value to a PEF-reference value [21]. Here, 5/8 had higher and 3/8 lower PEFs than the reference value, with maximum deviations of +137 and -86 units. None of the participants reported having difficulties in breathing. The study was conducted indoors in a dark room. Participants sat on a chair facing a wall 2 m from them, which was covered in black, non-reflective fabric. The participants held the BreathScreen prototype in their hands and blew into the mouthpiece. The BreathScreen prototype's projector was connected to a computer, from which the images for the evaluation tasks were presented. Two researchers were present in each study session, one moderating the test and one controlling the study equipment and observing. The sessions were video recorded, and transcribed after the test. Each study session lasted approximately one hour.

RESULTS

First impressions

The BreathScreen aroused strong positive reactions from the participants. The sudden appearance of visual images in front of the face was described as "*magical"* and the slowly fading images were found engaging. The effect of the moving surface of the fog screen was perceived as aesthetic, e.g.,*"It is so wonderful, when first blowing it appears so clearly, and then it starts to levitate and disappear"* (#F2).

Participants commented that the content has to be clear enough that it can be visually absorbed with only a single breath. Thus, it was reported that clear, simple and high contrast content is easiest to perceive, e.g. *"The content must be clear, not too detailed, as it is visible only for a while"* (#F3). The combination of the moving fog surface and colored content was described as giving a holographic or 3D-like feeling of the content, e.g.,*"I think the colored butterfly was attractive looking, it became somehow three-dimensional" (#F1).* The colors, with the exception of sepia, were all perceived clearly.

The act of blowing was considered a natural way to produce the screen in front of the face. The ability to form a screen by blowing in the air without any technical accessories was desired, i.e. cold breath outdoors in freezing temperatures, e.g. *"It is just a natural way to form a user interface. I would rather try it in the winter when there is no need to use that kind of additional tool"* (#M3)

Character Size and Quantity of Content

When charting the effect of the font size (Task 2), all participants could read characters with font sizes from 100 to 225 on the fog screen. Font size 75 was readable by 7/8 and font size 50 by 6/8. Font size 25 could not be read by anyone. When projected on a comparable solid surface 7/8 could read all characters at font size 25, whilst the participant with astigmatism was able to read all characters at font size 100.

Figure 4 shows the number of breaths and time used in task 3. The effect size of the screen format on task times was large (r = 0.8). A significant difference between the solid and BreathScreen cases was found between breath screen (M = 6.6 s) and solid (M = 1.8 s) cases, t(7) = 3.957, p = .005. When the quantity of content increases, the time and hence the number of breaths needed to comprehend the content increases. Blowing longer breaths and several times caused frustration and negative feelings for the participants. Also, the task of blowing, counting and assimilating the information at the same time was considered demanding, e.g. *"I blew to the end of my breath so I could see the whole line"* (#F2) and, *"It is hard to blow and calculate at the same time."* (#F4). The participants' uncertainty regarding the information increased as the information load and number of blows increased, e.g., *"Five, no it was six"* (#M1) and *"I think I know, but let´s check once more"* (#M2).

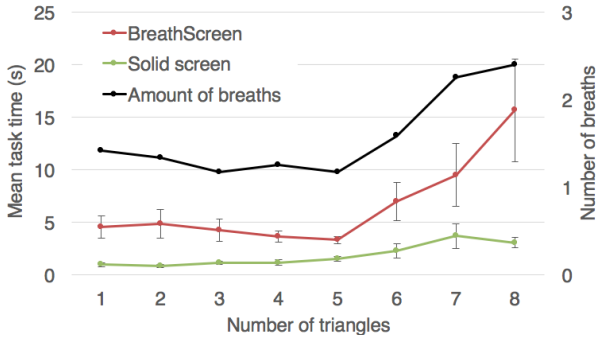

Figure 4. Number of breaths and time used in tasks related to amount of presented triangles. n = 6 (data from 2 users is not included due to technical problems)

Aesthetics, Ephemerality, and Effortless Interaction

Participants gave many positive comments related to aesthetics and ephemerality, commenting that the BreathScreen rendered images *"come alive"* in the hovering fog e.g. *"The aesthetic experience is just so exquisite and unique when the content lives along with the cloud´s movement"* (#M2). Also the term 'effortless' was

mentioned by several participants, referring to the ability to create a screen naturally by breathing, without any extra effort to open a gadget or operate switches. It was also mentioned that, compared to other screen solutions, BreathScreen´s ephemeral nature didn't hinder the visibility of the surrounding environment, e.g. *"This goes on and off momentarily and the real world is visible at the same time… this is a free and effortless way"* (#M2). The effortless interaction also linked with the possibility to use the BreathScreen outdoors in cold weather without needing the vaporizer or mouth piece, and enabling hands-free interaction, e.g. *"I would happily rather use that kind of momentary screen than fumble with a mobile or tablet with cold and numb fingers."* (#M3).

The biggest challenge emerging from the user study was the ergonomics of use. The prototype BreathScreen device required users to make relatively strong blows for it to function. For some, blowing with the BreathScreen prototype was noted as exhausting and especially persons who had to blow many times in a row reported that it was tiring to get content visible. For example, in Task 3 one participant commenting, *"Now I cannot blow anymore, otherwise I will faint"* (#F5). Participants' stressed that it should be able to get the content visible effortlessly with only light blows, and preferably with one blow only, e.g. *"It should be possible to get visible with a light blow, that it could be used by diverse people"* (#F1). The evaluation also revealed that an adjustable viewing distance is important, the 30 cm used in the prototype being problematic for some of the participants.

Application Ideas

Participants' ideas for BreathScreen usage focused mainly (7/8) on the experience industry and outdoor environments, and for both personal and public use. For personal use, it was proposed to give navigation or other short information when outdoors, e.g. during sport activities *e.g. "When skiing or hunting… I would follow where the dog is running or check how long I have been walking"* (#M2). Tourism, advertisement, use in amusement parks, events and fairs were given as examples of potential public use contexts, for the purposes of creating rich user experiences e.g. *"…unexpected things, in unexpected places, in unexpected moments"* (#F1) and *"...some sort of magic world´s magical navigator"* (#F2). Also, people working in dark and cold surroundings, and physically impaired people were mentioned as possible users of the concept.

DISCUSSION

Ephemeral and Experience Rich UI

Our study participants' feedback on the BreathScreen highlights its potential as an experience driven UI. The aesthetic experience was perceived unique and fascinating as the cloud movement gave a multidimensional and dynamic feeling to the presented content. The perception of pictures appearing and vanishing in the air was commented to create an almost magical feeling, in line with Vallgårda et al.'s findings on emotional responses with temporal UIs [31]. This ephemeral aspect of the BreathScreen was able to evoke emotional responses, and thus provide a start point for building affective, efficient and satisfying interfaces [30]. Moreover, taking ephemerality as a design driver offers new ways to tackle the growing information overload, and may lead to novel aesthetically designed interfaces for many yet unexplored domains.

Easy and Effortless Interaction

The easy and effortless interaction, where the UI is created naturally by exhaling, was a main strength of the BreathScreen concept, and should also be considered as a design driver for its applications. As well as experience driven use cases, the concept was also found to support utilitarian aspects. For example, BreathScreen could enable hands-free interaction in special use contexts (i.e. dark, cold outdoors). Here, noting that the current BreathScreen concept requires a dark environment, and when used outdoors, cold weather, low wind and the right humidity level to function well. Based on the findings from our study we recommend that interaction with the BreathScreen should remain short and the visualizations simple, such that long exhalation or multiple breaths are not required. This requirement also links with the universal design aspect to making BreathScreen accessible and comfortable for a wide cross-section of users.

Limitations and Future Work

During our study there were some technical problems with the BreathScreen prototype e.g. cracks in the assembly causing air leakage and water condensing inside the vaporizer deteriorating fog formation. This required some participants had to blow relatively hard and multiple times, causing discomfort and light dizziness. We recognize that our study is limited by its small sample size and controlled laboratory settings. However, we believe our findings have value to guide future researchers and practitioners to develop the concept further. As future work, we aim to optimise the BreathScreen parameters e.g. screen size and conduct an in-the-wild study with a larger number of participants, and with a BreathScreen formed naturally with exhaled breath clouds.

CONCLUSION

In this paper we have presented a breath-created fog screen, and the first user evaluation of the concept. The results indicate that BreathScreen is perceived as enchanting, engaging and experience rich, due to the ephemerality of the appearing and vanishing screen, its effortless interaction mechanism, and the movement of the rendered image on the fog. To ensure usability, the required strength and duration of blowing needed to produce the BreathScreen should be minimized, and the presented information should be simple and easy to digest, requiring only one exhale.

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