SpectroFlexia: interactive stained glass as a flexible peripheral information display

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ABSTRACT
In this paper we present SpectroFlexia, a form of interactive stained glass that is designed to present information in the periphery of people's attention. SpectroFlexia is developed in an iterative design process which revealed a low-cost method of smoothly changing the color of light shining through translucent materials. Using this method, SpectroFlexia can display several types of digital information through the speed at which its colors change. In addition to providing peripheral information, SpectroFlexia is designed to serve a decorative function. An informal user exploration with an interactive prototype of SpectroFlexia indicated that smooth color transitions are a promising way of presenting peripheral information.

Author Keywords
Peripheral Interaction, Awareness, Periphery, Information Decoration, Calm Technology, User Exploration.

ACM Classification Keywords
H5.2 Interaction styles

General Terms
Design

INTRODUCTION
In everyday life we are surrounded by an increasing number of information displays. Think about cell phones, laptops, signs, billboards: most these displays are designed to attract people's attention. With the increasing ubiquity of computing technology in the everyday world, people are therefor at risk of being overburdened with information. Already in 1997, Weiser and Brown [10] stated that "pagers, cellphones, news-services, the World-Wide-Web, email, TV, and radio bombard us frenetically." [10, p.74]. Also, van Mensvoort [8] criticises the obtrusiveness of current information displays, and argues that this may lead to information overload.

In the everyday physical environment however, a lot of information is present as well. Interestingly, this information often hardly attracts our attention. For example when reading a newspaper during breakfast, our attention is focused on the newspaper and not on other stimuli such as the sound of the coffee machine. Still we are able to perceive this sound, and will immediately react when it changes as the coffee is ready. The information is present in the *periphery* of our attention, but shifts to the *center* of our attention when it becomes relevant. Inspired by this human ability to perceive information in the periphery, Weiser and Brown [10] envisioned *calm technology*, technology which "engages both the center and the periphery of our attention, and in fact moves back and forth between the two" [10, p. 74].

We believe that implementation of the vision of calm technology in interaction design will support information displays to present information without overburdening. Displays which build on the earlier mentioned human attention abilities, enable people to perceive information in the periphery of their attention and only focus on it when this is relevant. This direction is also referred to as *peripheral interaction* [2]. While indeed such displays are at moments perceived in the center of the attention, the transition between periphery and center usually happens in a calm and subtle manner. In other words, a "smooth transition between levels of awareness" [4, p. 6]. Additionally, we believe that peripheral displays may, apart from subtly presenting relevant information, also serve a decorative function. This is inspired by the concept of 'Information Decoration' [8], which "seeks a balance between aesthetic and informational quality". Such information displays can provide peripheral information to users to whom this information is relevant, but can also be decorative to other users, whom may not even be aware of the fact that information is being displayed. We believe that this direction could be interesting in several contexts where multiple users are perceiving a display, such as at home, in the office or in a public space. Awareness of digital information streams is becoming increasingly important in such contexts.

This paper presents an innovative peripheral display called *SpectroFlexia*, inspired by stained glass, which can flexibly be linked to and visualize digital information by subtly changing its color pattern. After addressing related work, we will discuss the development-process, design, interactive prototype and an informal user exploration of SpectroFlexia.

RELATED DESIGN AND RESEARCH
Several related studies have been focusing on creating peripheral information displays, all trying to facilitate

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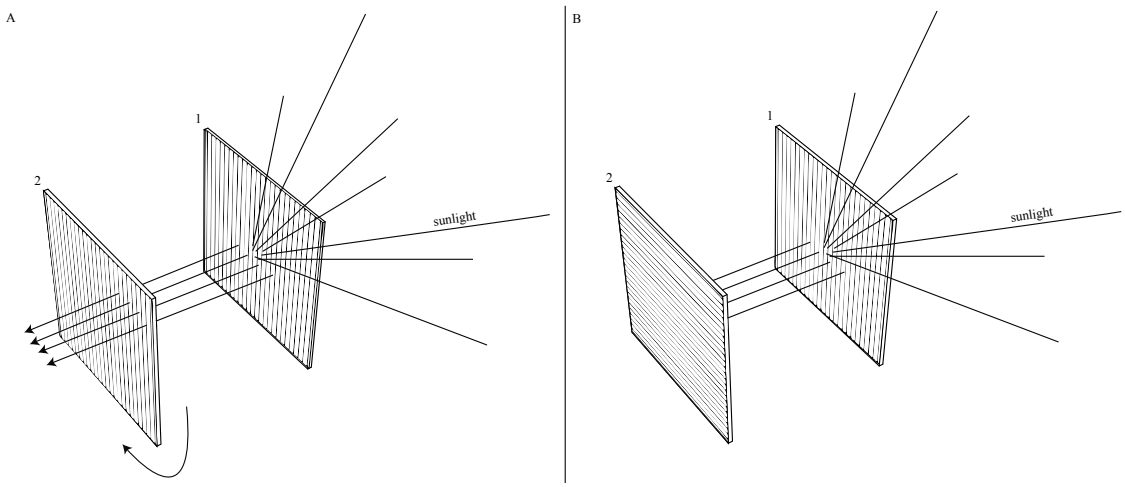

Figure 1. Illustration of the light manipulation method with two polarizers (1 and 2).

awareness of certain information. Dangling String [10], for example, subtly represents the network activity in an office by rotating a physical string to create a visual and auditory, peripheral display. The Water lamp [3] shows a subtly changing reflection of water ripples on the ceiling to display certain digital information, for example the heartbeat of another person to support the sense of connection. Short-term Weather Forecast display [6] project sweather forecasts of three hours in the future, on a window display, through pictures or animations of that particular weather type. Apart from these research oriented examples, commercial products are also known which display peripheral information. IVY [5] for example, is an external hard disk that shows its contents on its skin in an abstract manner. Agenda Wallpaper [1] shows the agenda as an abstract impression of your upcoming plans: it gives an overview of how busy you are during the week.

SPECTROFLEXIA

In the process of developing a peripheral display, we were interested in creating a display that does not only subtly present relevant information, but that could also serve a decorative function, as envision in the concept of 'Information Decoration' [8]. Inspired by the beauty of stained glass, we developed SpectroFlexia, an information display that uses color transitions to present digital information.

Design process: Hands-on Explorations

The development-process of SpectroFlexia consisted of numerous hands-on exploration of translucent materials. In this process, we exploratively discovered a simple and low-cost method to adjust the color of light that shines through translucent materials, which we applied in SpectroFlexia. We will now present the iterative process in which SpectroFlexia was developed.

Sunlight changing over the day was the starting point of SpectroFlexia's design-process, its smooth transitions were seen as an inspiration for peripheral interactions. We therefore explored how to manipulate sunlight to create a controlled interaction. We investigated the use of polarizing material to manipulate light. These polarizers are optical filters that can adjust the intensity of light by filtering out the mixed polarization into one single vector of polarization [7]. A method to manipulate sunlight is by directing a fixed polarizer towards the sunlight with a second rotatable polarizer in front of it, as illustrated in Figure 1. Figure 1 depicts two situations. In situation A the degree of rotation of the fixed polarizer (1) is the same as that of the rotatable polarizer (2), which allows light to shine through. When the rotatable polarizer is rotated 90 degrees, illustrated in situation B, no light will pass. This is a simple method to smoothly dim the intensity of sunlight.

Our method to manipulate the *colors* of light that shines through these polarizers extends this principle. By putting a plate of Polyethylene Terephthalate Glycol (PET-G) in between the two polarizers, the color spectrum of sunlight can be changed, as illustrated in Figure 2. Now when the rotatable polarizer (3) is rotated, the light that shines through smoothly transitions between different colors.

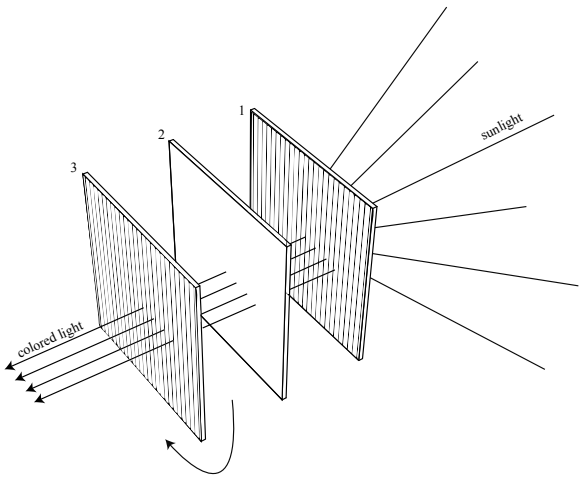

Figure 2. Illustration of the color manipulation method using two polarizers (1 and 2) and PET-G (3).

By implementing this color manipulating method we develop the information display SpectroFlexia, literally meaning the distortion of color spectrums. SpectroFlexia (see Figure 3) is an interactive version of stained glass, which makes users aware of one certain digital information by displaying color transitions at different speed levels. The displayed information can be any source of digital information, which can be flexibly selected by the user. Though SpectroFlexia can present one source of information at the time, the user can choose and change this information source as he or she wishes. SpectroFlexia is designed to be placed on a window, as illustrated in Figure 3. To explain the use of SpectroFlexia in more detail, we now describe an example usage-scenario of SpectroFlexia in a home context.

James has connected SpectroFlexia to the energy consumption in his household. Early in the morning, when James is having breakfast, the energy consumption is low and SpectroFlexia's color changes is therefore slow. As James starts up his computer, the color transition speed of SpectroFlexia increases. After checking his email, James notices that the colors of SpectroFlexia are changing even more quickly. He realizes that his wife must have woken up and is using the bathroom.

On Figure 4, two possible color transitions of SpectroFlexia for the scenario above are illustrated. The illustration depicts the begin and end phase in a time span of 5 seconds. In situation A the color changes slowly (the color slightly changed in tint), which illustrates low energy consumption. In situation B the color change is faster (the colors changed more in tint): more energy is consumed. Peripheral awareness of this information may not only help James manage his energy consumption, it may also increase awareness of certain events (e.g. his wife woke up).

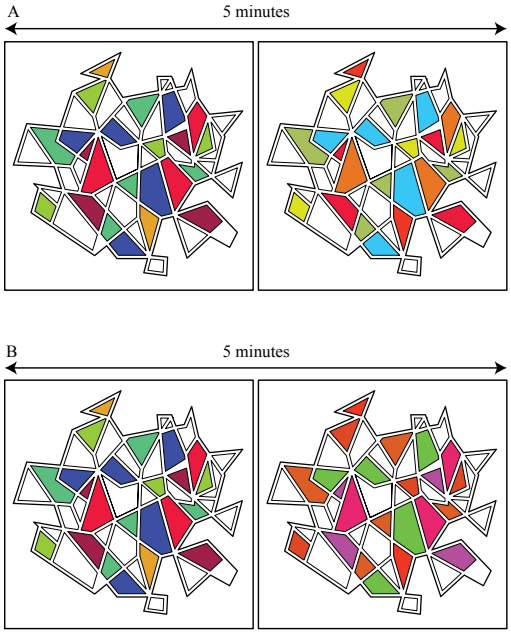

Figure 4. Illustration for the scenario, displaying the color transitions in different speeds

Figure 3. Picture of final prototype of SpectroFlexia.

Interactive prototype

During this study we developed an interactive prototype of SpectroFlexia, see Figure 3 and [9] a for a video demonstration. As illustrated in Figure 5, the prototype consists of a fixed plate of PET-G and a rotatable polarizer. As a fixed polarizer we used several small polarizers, decoratively placed in different rotation degrees to create different colors, giving it a stained glass look. The prototype further contains an Arduino controller which is connected to a laptop computer providing the digital information input that can be extracted from the internet. Based on the value of this digital data, the Arduino controls the rotation speed of a DC motor that is connected to the rotatable polarizer.

USER EXPLORATION

The aim of SpectroFlexia is to subtly present digital information in the periphery of people's attention. As part of the iterative development process of this peripheral display, we set up a quick and informal user exploration with the interactive prototype to see how users respond to the display.

During the user exploration, SpectroFlexia was placed on the window of a small office. In this context, SpectroFlexia visualized the amount of people working in the office; the

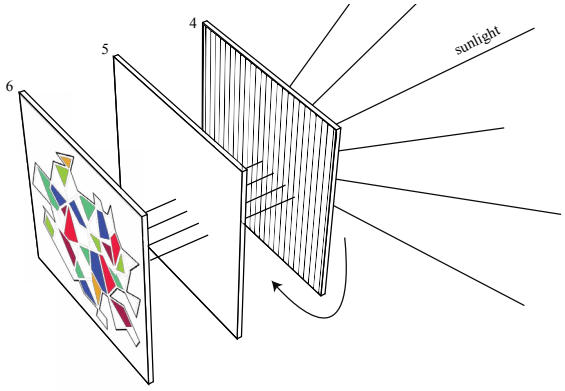

Figure 5. Illustration of the materials used in the SpectroFlexia prototype: a rotatable (4), a fixed (6) polarizer, and a plate of PET-G (5).

more people, the faster the color transitions. Five participants were recruited, none of whom were given any explanation about SpectroFlexia. Although users would normally select the information that is presented themselves, and thus be aware of the working of the display, we were now interested in exploring whether participants would understand what information was being displayed. The five participants each worked for 15 minutes in the office in which SpectroFlexia was installed. These five time-slots overlapped so that the number of workers in the room differed frequently. After the session, we conducted an informal interview with each participant in which we asked them what they noticed of SpectroFlexia's color-changes and how they experienced the display in general.

All five participants noticed SpectroFlexia and realized that its colors changed. Three participants were able to link the color changes to the number of people in the room. Some participants described the changing speed of the color transition as smooth or subtle, while it was mentioned that the display should be enlarged to be clearly visible from larger distances. Although this user session was only a quick and informal exploration of the user experience of SpectroFlexia, the results seem to indicate that our idea of subtle color-changes on interactive stained glass seems a promising way to display peripheral information.

DISCUSSION

The design presented in this paper, is inspired by the concept of information decoration [8], which aims to combine the function of information display with a decorative function of interactive technology. Although this latter aspect was not a part of our informal user exploration, we see SpectroFlexia as a decorative artifact as well. Since SpectroFlexia can flexibly be connected to one source of digital information, the displayed information may be more relevant to one user than to another. In such a situation, it is obviously important that the display is not obtrusively attracting the attention of people to whom the information is not relevant. Therefore, we believe that SpectroFlexia could serve a decorative function to those who do not use its informational function.

During the iterative development process of SpectroFlexia, we exploratively discovered a low-cost method of manipulating the color of light shining through a translucent material. Using this method, the SpectroFlexia prototype can be located on any window. Although the prototype is only a small artifact, the materials allow covering larger surfaces as well. Spectroflexia could thereby be integrated in various interiors or even embedded in windows, customized to match the interior style of a particular environment.

CONCLUSIONS

In this paper we presented the peripheral display SpectroFlexia, interactive stained glass which can flexibly be connected to digital information. This information is displayed through the speed at which the colors of SpectroFlexia change. Using an iteratively developed, low-cost method of adjusting the color of light shining through SpectroFlexia, an interactive prototype was realized which enables smooth color transitions. An informal user exploration with SpectroFlexia indicates that this approach seems a promising way to display peripheral information.

This paper adds to existing work in the area of calm technology and physical interaction in general by presenting an innovative example of a peripheral display, which combines the functionality of displaying peripheral information with a decorative function, suitable for several contexts of use such as the home, the office or the public space.

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