# Graphic Interaction in Fashionable Wearables - Apps and Services for Smart Watches

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**ABSTRACT**

Digital devices, e.g. smart watches, are increasingly worn in similar positions on the body as clothes and accessories. Some wearables have screens on which graphics is publicly visible. Such wearable displays provide endless variation of visual expression and we foresee the need to develop fashion-oriented software and services. Disregarding fashion thinking that generates appeal and desire for the clothes and accessories we wear might lead to user dissatisfaction and missed opportunities. In a three-step design study, we investigate the use of smart watches in stylish men's dressing; then we invent and design a service called "Watch for Figuracy". It is an interactive watch face, which is contextually dependent on the wearer's dressed ensemble and matches colors based on culturally established color principles. Finally we conduct an initial user feedback study, which suggests the potential of fashion wearable hybrids and indicates shortcomings in utilizing color theory for matching the watch face to the outfit.

**Keywords**: Wearables, fashion, smart watches, outfit, watch face, Watch for Figuracy

**Index Terms**: K.6.1 [Management of Computing and Information Systems]: Miscellaneous

## 1 INTRODUCTION

There is an on-going trend where digital devices are used in close physical proximity to our bodies, similar to clothes and accessories. It started with the success of mobile phones and continues with the emergent use of smart watches and wearables. Sociological research [15] has argued that since mobile phones are handled and interacted with close to our bodies, which is shared with clothes and accessories, the interests in beautifying the devices are increasing. If that is true, we could assume that users of wearable technology would also be concerned with the visual aesthetics.

Previous research on wearable technology has focused on allowing interaction on small screens as well as investigating how to provide "utility" oriented services. First, in HCI, a wristwatch "is an attractive form factor for a wearable computer. It has the advantage of always being with you" [32]. The challenge is then to allow interaction given how the body-position limits the size of the screen. It generates a long-standing concern in improving the interaction and usability on such devices. Second, research has also focussed on providing utility and functionality on wearables, such as health analysis or sport performance [11].

We argue for a new concern that requires introduction of fashion thinking e.g. when designing graphic interaction. This approach is motivated for two reasons. First, it has been argued that one of the barriers to consumer acceptance of wearable technology is that the aesthetics of these devices does not fit the changing fashion trends in clothing consumption and some wearable research is rejected in user studies because the devices are unpleasant [23]. Second, the potential of using fashion thinking in designing wearable services is still unidentified. If users of wearable technology expect to experience these devices in similar ways as their clothes and accessories, the way to design them should then be inspired by fashion design and practices.

In specific, we investigate how graphic interaction in wearable devices should vary visual expressions in order to be experienced as fashionable items. Fashion and its connection to product design and interaction design are already attracting increased attention among HCI researchers, e.g. in studies of sustainable fashion design [31], wearable computing [3], and mobile design [19]. HCI researchers have started to explore innovative ways of enhancing aesthetic variations. For example, Juhlin and Zhang investigate how flexible hardware, informed by emerging research on organic interfaces, could create aesthetic variation to adapt to different looks in dressing [20]. However, currently available wearable technology with publicly available screens, already provide concrete opportunities to increase the aesthetic variations, e.g. by developing new software and services. Thus we here investigate *how to create fashion software and services for graphic interaction on the screens of wearable devices*. The relevance of this topic is likely to increase, given the growing interest in manufacturing and commercializing a type of wearables called "smart watches", i.e. computerized watches connected to the Internet [32].

At this initial stage, we aim for knowledge that is "generative and suggestive" [16]. Therefore, informed by Sas et al. [33], we apply a design research approach, which combines three delimited studies into a single entity. First, we conducted a *fieldwork* study of "Sony smart watch 2" *as the source of design implication,* which complemented the existing research by investigating the aesthetics of such watches in dressing practices. Second, we designed and built an *instantiation of system*, called "Watch for Figuracy" *as a concrete exemplar of design implication*. We focus on the watch face, since telling time is likely to be the most common and regularly used software when attached to the wrist. The app not only works as a "color stylist" that recommends the right color displays, but also enables the watch display as part of the wearer's dressed ensemble. Third, we conducted *an initial feedback study* on the app and gained design implications through qualitative interviews, instead of a quantitative usability test. The interviewees created twelve outfits with the app. They showed general interests in connecting the appearance of the watch face to their outfits. It revealed both acceptance and rejection of the "fashion intelligence" implemented in the system.

The paper is structured as follows. First, we present related work that inspires our designing wearable displays for fashion purposes; second, we introduce the research through design

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method to explore the design space; then, we present the three studies in details. These are followed by discussions of how to create fashion services for wearables that provide public displays and adapt to the changing outfits with our design as an example.

## 2 RELATED WORK

Our idea of creating fashion services for graphic interaction on wearable devices is influenced by current smart watch research in HCI; fashion studies and wristwatch fashion; and the opportunities that public screens of wearables bring to design.

### 2.1 Smart Watch Research in HCI

Smart watches are commonly defined as "wrist-worn devices with computational power, integrated sensors, connectivity to other devices or Internet and integrated clock" [4]. Global technology companies, e.g. Samsung, Sony, Motorola and Apple as well as small start-ups, e.g. Pebble and Martian are releasing a range of models. Research in HCI focuses on the usability or technical aspects of smart watches, such as the design of user-friendly interfaces for small wrist-worn displays [25]; new forms of interaction modalities [7]; sensor requirements [5] and text-entry technologies [12]; or how to design wearable devices for a special group of people, such as the disabled [39]. There are only a few studies concerning the aesthetic aspects of smart watch or other wrist-worn devices e.g. studies which propose using LEDs to design aesthetic display of wrist-worn jewellery [14]. In all, there is a lack of aesthetic aspects in smart watch research in HCI and we will try to fill this gap in this study.

### 2.2 Fashionable Dressing and Wristwatch Fashion

Fashion is an important driver of taste and it moulds our concept of what is considered beautiful and aesthetical [19, 37]. Fashionable dressing is an important everyday activity and is driven by features such as the following. First, it is done to make public visual statement to "win approval or respect by appearing stylish, sophisticated or chic" [19, p94]. It is intrinsically public, since the aim is to make statement and show off. Then the idealization of the visual appearance of human bodies or simply put, the image of the body, is much more important than the real biological bodies. Second, it produces a "look" comprised of various items, which is usually done through mix-and-match activities. From the perspective of fashion design, designers often create a collection of outfits, not just one single item. Star designers usually have their own signature look. For instance, Chanel's iconic look includes "outfits developed from the tweed cardigan jacket… but made contemporary, light and feminine,…worn with tiny curving skirts that drew on the organic forms of seashells for their delicate silhouettes" [1]. Fashion consumers mix different pieces together to create a look. Wilson argues "getting dressed" in the modern world is a matter of bricolage, of the coming together of garments and accessories, combined to create a finished "appearance" [37, p248]. The use of wristwatches is established as topic of inquiry in both the field of fashion studies and broader fashion media, especially in men's fashion. It is seen as "man's most prominent accessory" [35, p181], which emphasizes its being part of a dressed ensemble. Hibbert et al. argue that the watches by Swatch, one of the biggest watchmakers in the world, "came in colors and designs to match—or clash with—every outfit" [17, p45]. We could also find similar attention from popular fashion media. For instance, editors from GQ claim that a watch is "one piece of man jewelry… it punctuates an outfit" [41]. Third, in dressing, fashion conscious people are constantly looking for new styles. People aspire to vary between new looks at an increasingly rapid rate [24]. The production cycle has become shorter in conjunction with consumers' demands for change and novelty. This also emphasizes that fashion is a process where the new constantly replaces the old. Fourth, fashionable dressing is socially constructed and influenced by culture, context and history [21]. It is done through e.g. a "fashion system" which means institutional and cultural arrangements that cause particular cultural objects to be adorned in a specific way [21]. Fashion requires its followers to not only express their uniqueness, but also conform to institutionalized norms and rules. In sum, fashion theory provides inspiration in considering how to provide graphic interaction on wearables, but does not per se provide design research insights.

### 2.3 Clothes and Accessories as Wearable Screens

Emerging wearable technology provides users with immense possibility to vary the visual expression, as compared with traditional garments. Dunne argues that wearable technology "allows our personal devices to understand our context, activities, and needs implicitly, and shift color, texture, and shape to provide endless customization [10, p42]". In previous research, the variation of aesthetic features is usually conducted through biometric sensor data and algorithms that should support health or the environment[3], such as a "heartbeat" dress that uses a red light-up electroluminescent panel to display the wearer's heartbeat [11]; the "Baroesque Barometric Skirt", which changes visually as the wearer moves around environments [2]. So far, there have been few attempts to understand fashion as the context that could drive the visual variation. One example is the "Lume" collection, which is an electronically infused clothing collection, which integrates changeable and user customizable elements driven from a smart phone [44]. Even though such technology is mainly available in research, it points to the increased relevance of asking how in specific the aesthetics should vary.

## 3 METHOD

We apply a Research through Design (RtD) approach [40], where the goal is to generate design implications through a concrete design exemplar, rather than offer a solution to an existing problem. In specific, our approach includes the following three steps informed by terminology developed by Sas et al. [33]:

1) *Fieldwork is common a source for design implication*. In this case we conducted a qualitative study of "Sony smart watch 2" use. It was needed to complement existing usability-oriented smart watch studies with an investigation of aesthetic aspects, especially the experience of such watches in dressing practices.

2) *Design and instantiation of a concrete exemplar*. We designed and built a concrete exemplar system, called "Watch for Figuracy". The design was generated through an iterative process, including brainstorming workshops, sketching, prototyping, building and testing. In this process, the learning from the fieldwork study was combined with an understanding of current mobile technology, color matching principles and theories of fashionable dressing.

3) *Initial feedback study*. Finally a small user study [9] was conducted with five male users. It helped us to reflect on the design concept and the exemplar system. In all, the three steps enable the articulation of the importance of visual aesthetic experiences in wearable design more broadly.

## 4 FIELDWORK

In the following, we focus specifically on the visual interaction with these devices, when a watch face is presented on its screen. A smart watch is a "smart" device, but also a "watch". The latter

indicates the smart watch shares some experiential qualities with a wristwatch. It is expected to do so not only because it is located on the same place on a human body as a watch, but also because it shares the functionality of displaying time and date.

We recruited seven male participants and let each of them experience a Sony smart watch 2, provided by us, since we at this time struggled to find users who had already purchased such a device. The device was selected, since it was highly ranked at the time [42] and it could connect to any Android phone.

The participants were selected based on the following criteria: First, they are fashion conscious male. This is informed by fashion literature, which argues that a wristwatch is of special importance for men's fashion [35]. Second, the participants wear wristwatches and they have already an extended experience of such object. Lastly, they had an Android smart phones, with which the smart watch could be connected. During the recruitment, we communicated with the applicants who showed interests in participation through emails and confirmed that they fit the three requirements. It is possible for one to articulate the interests in fashion. The participants were all self reported as style conscious men, as they "spend time in dressing before going out", "think carefully what to wear" and "like to show their own styles". They were in the 20s and 30s. They were asked to use the device for a month in order to ensure that they could experience it during many parts of the everyday life. They were interviewed and the recordings were transcribed. We apply qualitative content analysis to interpret the transcripts from the semi-structured interviews, where we identify interesting themes by summarizing the answers with our research question and relevant theories in mind [27]. All participants are anonymized.

### 4.1 Experiencing the Watch as Part of a Dressed Ensemble

The participants considered the experienced of the smart watch as a potential part of their outfits. This orientation was visible in concrete decisions on what to wear, as well as the choice of strap on a particular smart watch. When it came to describe their everyday wristwatch, they all understood it as an accessory to their dressed ensemble. For instance, Mark said:

*The watch I used a lot has an orange face and one big circle and two smaller ones. It's designed with chromium details and a light brown strap. Good for wearing light colors, but not so good with black jackets. Another one I use occasionally, has a metallic strap; some kind of weird holographic face, which looks very cool […] This is more for formal events, with black suits.*

Mark described how a wristwatch matched other clothing items. The watch with an orange face went together with light colors, and it had a holographic face which could be combined with black suits. In line with the fashion literature on wristwatches, our participants treated their wristwatches as a complement to their outfits. The same consideration was observable in their experiences with the smart watch, since they also cared about matching between this and other clothing items. It shows that color was an important matching mechanism.

### 4.2 Desire for Variation

People's urge to change dressed ensembles is another key feature in fashion [21]. The wristwatch is typically used more often and over longer times than clothing items. Still, the interviews indicated how its use was shaped by a desire for change. All participants had at least two wristwatches so that they could adapt to different styles. They all approved of the possibility to vary between several watch faces. For instance, Simon said:

*One thing that I liked is the idea that you can change how the watch is presented. Then you could have analogue, digital, or whatever. You can have a customized watch face.*

Since the watch face is graphically emulated on a screen, rather than made in hardware, its visual appearance can be altered. The participants appreciated the opportunity to vary the looks of the watch face. This indicates that the orientation to change concerns both hardware and software. The desire for variation was also linked to their participation in various social settings. An object appropriate in one setting might be less so in another setting. Therefore, our request for the participants to try out the new technology during a period became an issue, as Simon stated:

*I used it a lot in the beginning. But then less and less. I didn't use it at all in the last week. It can't go with everything. You can go with a T-shirt, jeans and school dressing, but when you go out for dinner, it doesn't look good. It looks nerdy.*

The smart watch could be part of his casual outfits. However, he lost interests in it after a while, because its visual appearance could not match all social occasions.

In sum, all participants gave positive feedback on the possibility of changing the watch faces on the screen of a Sony smart watch 2. However, they were not satisfied with the particular pre-installed designs. It also showed how they experienced the watch as potentially matching it with an outfit. It remains to be discussed how to account for those interests in design.

## 5 Design Instantiation

The field study inspires to further consider a smart watch as a fashion item that is experienced as a combined ensemble together with other clothing items, which should also be visual and publicly available for co-present people. Using an approach similar to the idea of "outfit-centric" design [19], we intended to vary the visual presentation of the watch face on a smart watch in a way that would account for the clothes a user is wearing. To illustrate and study the idea, we designed and developed an application called "Watch for Figuracy". In the following we introduce this application and our specific design decisions.

### 5.1 Matching Watch Faces to Colors in Dressed Ensembles

When people put together a dressed ensemble they consider a wide set of visual characteristics such as color, pattern and surface structure. We chose to focus on matching the watch face colors with those on the worn items since this feature has been considered by professional along time; they are easy to implement although not yet used in mobile design.

First, *the color of individual clothing items plays an important role in professional advice on selecting a combined outfit [6].* The use of color theory in creating fashionable dressed ensembles dates back two centuries. The French color theorist Michel-Eugène Chevreul has had much impact on how fashion writers give advices, since the mid-19th century. His theory provides "laws" on the appropriate combinations for different complexions [29]. Contemporary dressing involves many more pieces of clothing, which bring about increased intricacy, but the principles are still familiar to design professionals. The rules are often illustrated with the so-called color wheel, which is widely used by fashion stylists to enhance outfits [43].

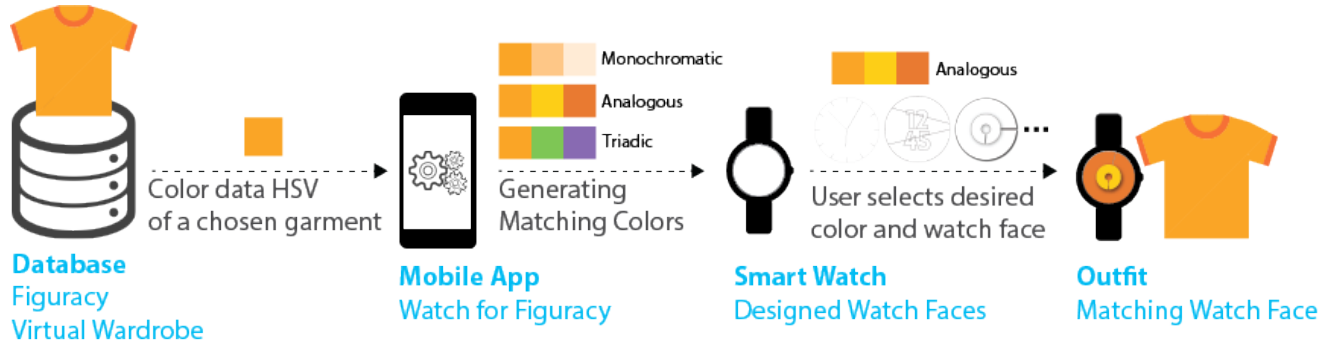



Figure 1 System of "Watch for Figuracy"

Second, the theory presented provides rules that are rather easy to implement as a matching algorithm. For the purpose of designing an initial service, it is an available and articulated aesthetic theory that describes how matching should be done. The theory commonly provides nine categories, of which we choose three: a) *Monochromatic* colors that derive two new colors from the same hue i.e. different additions of black. It provides a strong sense of visual cohesion; b) *Analogous* colors that are close to each other on the "wheel" and tend to look harmonious together because they are related; c) *Triadic* colors that are equally spaced around the circle and give a strong visual contrast, while retaining balance and richness [6].

That said, we recognize that more advanced matching algorithms are soon available by combining visual search and big data analysis [23], such as that proposed by Iwata et al. [18]. They have developed a system that recommends a new clothing item from the user's wardrobe, given a selected item. It draws on analysis of outfits available in full-body photographs from fashion magazines. It is highly relevant as it accounts for fashion institution, e.g. fashion magazines. However, in this initial design study we chose to start the investigation with a less complex system implementation.

Third, although the color theory has been used by designers for a long time, the basic principles is not commonly known among laymen. People tend to wear similar color tones to "match", i.e. "monochromatic" matching. This simplistic principle is e.g. utilized in mobile services such as the smart clothing app called the "Lume collection". It allows the wearers to choose a tint from their accessories with a mobile application, and then the same dye will be displayed on a "smart" collar [44]. However, as we have argued, colour matching is more than monochromatic display and provides exciting variety.

## 5.2 Design and Implementation

Based on the chosen color matching principles, we designed and developed a smart watch application called "Watch for Figuracy" (see attached video), which enables the users to choose a desired watch face and match its color with the clothes he/she is wearing. It works on all Android Wear smart watches. We developed a system (Figure 1) that can roughly be described as consisting of three components:

1) a database where the users' clothing items are digitally represented and stored;

2) a controlling mobile app, by which the users can choose the item they want the smart watch to match with and the desired watch face color from the colors proposed by the app via color matching principles and algorithm;

3) an output watch face that matches the wearer's outfit, which the user can select from a set of designed watch faces. In the following, we describe the system architecture in detail.

### 5.2.1 Figuracy as a Database

In order to adapt to a wearer's outfit, the system must be able to acquire information of the colors of the worn clothing items. There are various ways to reach the goal, but we chose to use the commercially available "Figuracy" service [46]. It is a website application where the users create their virtual wardrobes by uploading information e.g. brand, color, size and photos of their favourite garments. This service was extended with a way to select items that were currently used in our design. This solution was selected, over e.g. using a mobile phone camera, since the users only need to input information once. It was also influenced by the increasing availability of digitized wardrobes. There exist a number of commercial mobile applications, e.g. Pose and TouchCloset, which allow users to manually input clothing items and then make combinations into outfits.

### 5.2.2 Watch for Figuracy as Mobile App

In specific, the system is realized through a mobile phone application for Android devices. It works as follows:

1) *Selecting a clothing item*: The app connects to the Figuracy database and displays the user's clothes items and their colors. The user can select what clothing item he/she is wearing and wants to match with the watch face.

2) *Picking a color*: Via a color picker function, the app then extracts the color value of a pixel on the picture. The pixel is selected by the user pointing to a specific area on the photo. The input dye is converted to HSV (Hue, Saturation and Value).

3) *Generating matching colors*: The matching mechanism was implemented accordingly in order for two of them to generate hues that were not used in the outfit, but still would complement it. Thus, by starting with a tint derived from a clothing item, we could generate three other colors for each matching principle.

### 5.2.3 Watch Face Graphics

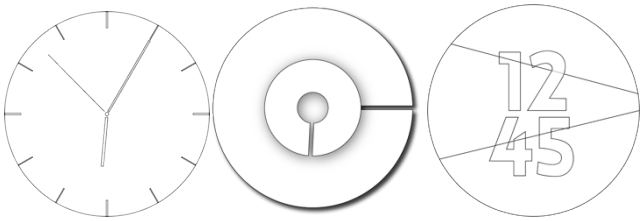
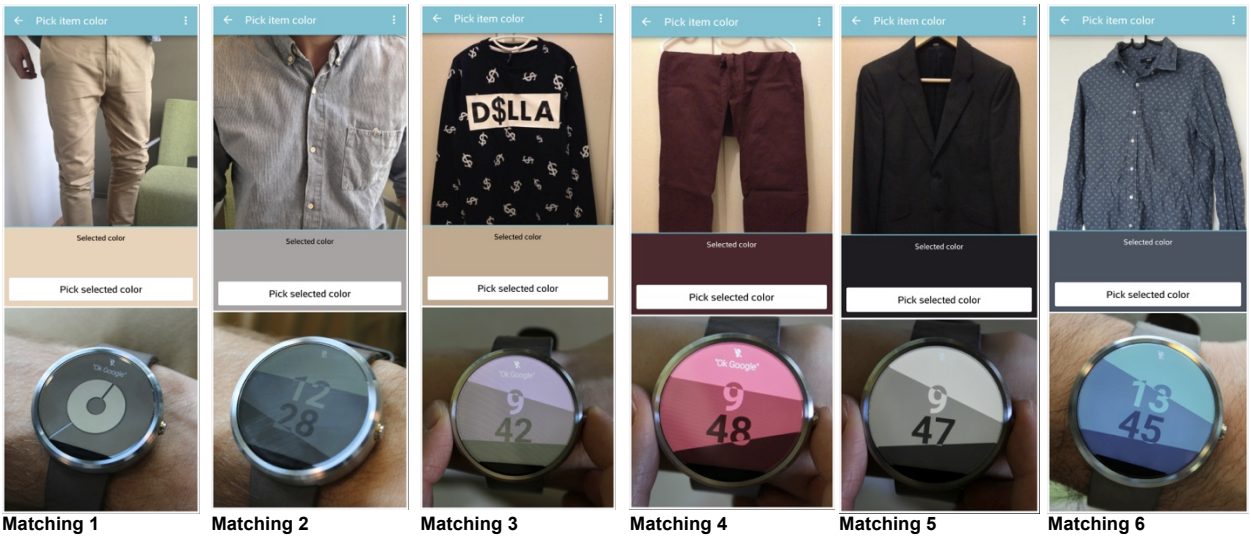



Figure 2. Watch faces designs without colors: Classic, Analogue and Digital (from left to right)

The watch face graphics consists of three designs (Figure 2), which can be selected following the standard interaction techniques in Android Wear. The selected watch face is then colored by the matching algorithm. Figure 2 shows three examples of our "un-colored" watch faces. The user can choose the preferred watch face to match their outfit (see attached video). The graphic designs attempt to provide a variety of styles. We designed the classic and digital styles, which emulate the faces of a wristwatch influenced by the wristwatch fashion. The screen of a smart watch also enables more interesting visual effect, e.g. the animation effect on the digital face (Figure 2). Additionally, we provide an abstract analogue face design showing the potential of increasing graphic variations on the display of wearables.

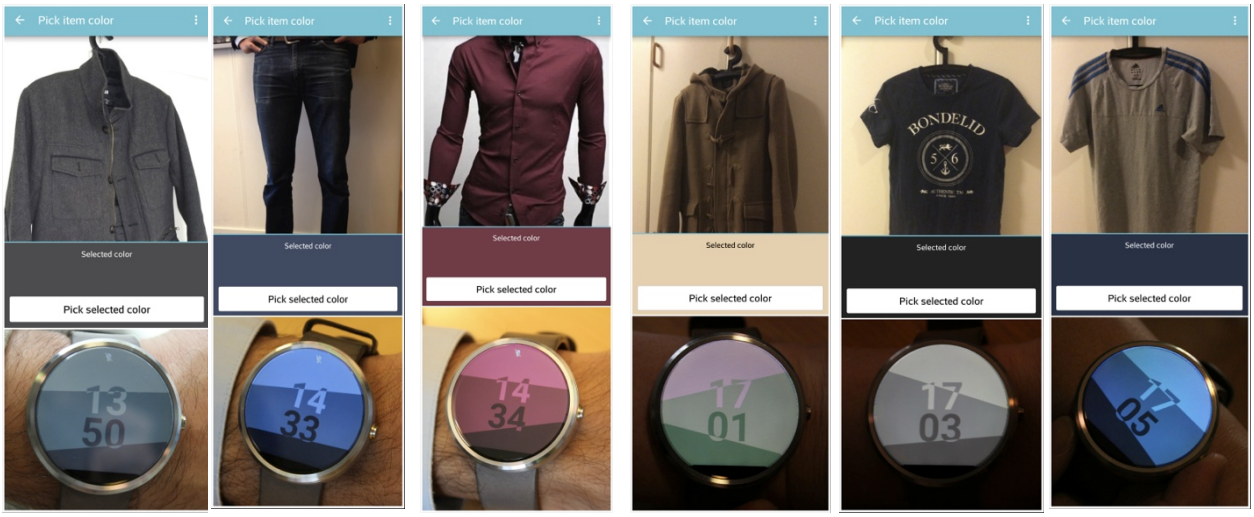
## 6 INITIAL USER FEEDBACK

We conducted an initial user study in order to acquire early feedback on the concept and the prototype experience. It included trials and interviews with five men in their 30s. They were




| Matching 1 | Matching 2 | Matching 3 | Matching 4 | Matching 5 | Matching 6 |
|---|---|---|---|---|---|
| **Participant**: Alfred<br>**Color principle**: Monochromatic<br>**Watch face:** Monochromatic<br>**Matching item**: A pair of beige pants | **Participant**: Alfred<br>**Color principle**: Analogous<br>**Watch face:** Digital<br>**Matching item**: A grey shirt | **Participant**: Leo<br>**Color principle**: Triadic<br>**Watch face:** Digital<br>**Matching item**: A black sweater with beige patterns | **Participant**: Leo<br>**Color principle**: Monochromatic<br>**Watch face:** Digital<br>**Matching item**: A pair of dark red pants | **Participant**: Leo<br>**Color principle**: Monochromatic<br>**Watch face:** Digital<br>**Matching item**: Black suit | **Participant**: Matthew<br>**Color principle**: Analogous<br>**Watch face:** Digital<br>**Matching item**: Dark blue shirt |

Table 1. Table 1 Variations of matching: Alfred, Leo, Matthew




| Matching 7 | Matching 8 | Matching 9 | Matching 10 | Matching 11 | Matching 12 |
|---|---|---|---|---|---|
| **Participant**: Matthew<br>**Color principle**: Analogous<br>**Watch face:** Digital<br>**Matching item**: Dark grey jacket | **Participant**: Philip<br>**Color principle**: Monochromatic<br>**Watch face:** Digital<br>**Matching item**: Dark blue jeans | **Participant**: Philip<br>**Color principle**: Monochromatic<br>**Watch face:** Digital<br>**Matching item:** Dark red shirt | **Participant**: Mike<br>**Color principle**: Triadic<br>**Watch face:** Digital<br>**Matching item:** Brown coat | **Participant**: Mike<br>**Color principle**: Monochromatic<br>**Watch face:** Digital<br>**Matching item** Black T shirt | **Participant**: Mike<br>**Color principle**: Monochromatic<br>**Watch face:** Digital<br>**Matching item** Grey T shirt with blue strips |

Table 2. Table 2 Variations of matching: Matthew, Philip, Mike

different from those in the fieldwork study since we did not aim to compare this app with previous designs of smart watches. The concept is targeted at fashion conscious men in general. The anonymized participants were recommended by the researchers' friends and colleagues as stylish men.

Every trial and interview lasted about 30 to 50 minutes. We provided each participant with a Moto 360 smart watch and an Android smart phone, with the app pre-installed. Moto 360 was chosen, because it was the first round smart watch that resembles the shape of many men's wristwatches [45]. We used the participants' own outfits as input to the system, to make the study as realistic as possible. They were asked to create an account in Figuracy and add clothing items before or during the test. Four trials were done in a lab environment, e.g. in offices; one was done at the participant's home, depending on the preferences of the participants. After logging in with their personal accounts, we asked them to select a watch face for each garment they had stored in Figuracy. After exploring the alternatives and the colors picked from the images, they selected one watch face with matched colors for each garment (see Table 1 and 2 for all resulting instantiations). They could either choose the pre-selected colors that the app picked on the image, or move a finger on the picture of a garment to pick another color. After the study, we asked them to comment on the concept and the experience. The interviews were all tape-recorded for later analysis.

**The concept:** Four participants expressed strong interests in the idea of changing the color of the watch face in response to current outfit, such as Philip stated "*I love it… it is so easy to change the watch face and match it with my clothes*". The interaction was considered to be fluent and the app easy to use. Some of them suggested design improvements. For example, Matthew proposed that the app should catch the colors directly through instant snapshot, making it independent from the Figuracy database.

**The size of a color field**: Eleven out of twelve instantiations utilized the digital face (see Figure 2) and none of them picked the classic form. Their comments were both usability oriented ("*easier to see the time*") and aesthetics oriented ("*the only face that had some animation effect*" or "*colors were more visible*"). The importance of the size of the color fields was indirectly acknowledged by another participant Mike. He stated that the alteration between forms did not matter much since the display was too small. The concept would be more interesting if it altered a bigger display. Thus, the reliance of the design idea is linked to the surfaces on which the app works.

**The experience of automatic contrast selection:** The monochromatic color selection mechanism was most popular (7 out of 12). The analogue principle was used three times and the triadic principle two times. As described, the latter two principles add different colors, whereas the monochromatic principle only varies in adding different grey scales of the same color. The users' feedback was then not clear-cut. It seems that the participants select a watch face with the same color as in their garment, as much as allowing the algorithm to automatically provide other matching colors. Interestingly, one participant suggested that the matching principles could apply to different social contexts. Monochromatic matching was more formal, while triadic matching could be used for parties. Additionally, one participant wanted to match the color of the watch face with that of the strap.

**The color picker:** The participants complimented the color picking, which was based on a combination of automatic selection and possibilities to override it with a manual selection. Manual selection was preferred, especially when the garment contained different hues (e.g. no.3 and no.12). Leo chose to match the face with the beige pattern on the black sweater.

In sum, the initial user study showed how they used both automatic contrast selection and monochromatic selections as well as how important the size of the visual fields was.

## 7 Discussion

The three-step approach, including studying available smart watches with wristwatch users; designing a service and conducting an initial feedback study, provide initial answers to how to create fashion software and services for graphic interaction on the screens of wearable devices. In the following, we will further discuss the implications for such fashion inspired designs.

### 7.1 Variation through Apps and Hardware

We focused on creating aesthetic variation, displayed on the screens of wearables. Fashion studies show that a constant variation in-between clothing items and a chase of news value are critical in fashion. The variation is shaped by fashionable people's orientation to shifting social contexts as well as aspiration to new looks [24]. Our fieldwork study shows that the participants all shared the interests of making changes of display on watch faces to present different visual styles. It also shows that existing ways of making aesthetic variations for wristwatch in dressing practices are quite low tech, including buying various watches or extra straps for one watch. Previous research on wearable technology shows that there are high tech ways to make the variation, e.g. being driven by bio or environmental data through sensors [10]. But these methods do not account for fashion values. Our "Watch for Figuracy" provides an example of software that varies the visual presentation on displays of wearables in ways driven by fashion mechanisms. People control the watch face by an application connected to android phones and the output is an aesthetical watch face display in the idle-mode. Thus, the visual output on the screen is controlled by software. This approach allows designers to generate unlimited graphic interfaces. The initial user feedback shows that the participants were generally content with experiencing the app. They created altogether twelve outfits, presenting different watch faces to match different clothes through the application (Table 2 and 3). In sum, wearable devices provide opportunities to increase the variation of aesthetic displays by developing fashion software.

### 7.2 Graphic Visualizations as Part of a Dressed Ensemble

To make wearable devices "fashionable", we suggest that their graphic displays offer public aesthetic expressions which match the user's outfit. According to fashion studies, fashion aims to make public fashion statement and impress the audiences around. Dressing is to create an "outfit", comprised of various items, which is usually done through mix-and-match activities [37]. In fashionable dressing, visual aesthetics of an item, i.e. clothing or accessory, is experienced in the context of an ensemble of clothing items. This is reflected in our fieldwork study where participants considered smart watch as a problematic fashion accessory. They were not satisfied with the aesthetics of the smart watch, since it did not visually match their styles and clothes.

This understanding informs how we would conceive variation in watch face display on a screen. If it follows the way people orient to dressing, its appearance would relate to the visual aesthetics of surrounding objects e.g. shirts, jackets or trousers, in other words, it should have some kind of fashion "smartness". Our design of "Watch for Figuracy" makes it possible to change according to what you are wearing. Here we see an interesting opportunity for designing wearable interfaces that accounts for dressed ensembles. It would provide software, which increases the

turnaround of the display of the devices, and does it in such a way that it fits with a person's dressed ensemble. Of course, making the watch display visible to the public all the time is challenging. Although this prototype can only display the color when the watch is turned on, this problem will probably be solved in the future when innovative material is used, e.g. color e-ink. Our initial user study shows that the participants generally expressed strong interests in making the display of the wearables matching their dressed clothes. However, one participant also points out that the small display of a smart watch might be not as interesting as bigger displays, since the watch is too small to be "visible". It implies that the size of the display is critical for adapting the visual presentation to outfits.

### 7.3 Fashion Algorithms

We chose color principles as an example to explore how to turn fashion mechanism into graphic algorithms running on wearable devices. Both fashion historians and contemporary fashion editorials suggest that some color principles are culturally and universally established as a basic tool for matching clothes [29]. They are in this sense institutionalized rules in fashion practices. Furthermore, the principles are also made available for algorithm. They are not only used in various commercial applications for recommending matched clothes, but also an important topic for the research field of graphic design and computing. However, existing HCI research on color focus on the technical aspects of color and visualization [13]. Little has been done on how color theory can contribute to designing graphic interaction for fashionable wearables. Our fieldwork study reinforces the importance of color matching between the wristwatches and the clothes people are wearing. In the design of "Watch for Figuracy", using color principles to influence users' decisions is an attempt to "mechanically" imitate fashion literature, where experts apply color theories to give advices on how to match clothing items.

Our initial user study offers two insights. First, it shows that we need to further investigate how to account for more complex fashion institutions. The participants showed strong interests in the concept of using color principles to match their clothes. However, they selected the monochrome mechanism more often than other principles. This mechanism is a sort of 1:1 color relation to the manual selection when putting on their clothes and accessories. Thus, in these cases they did not use the "fashion intelligence" provided by the app. These findings are obviously not conclusive. The study is small and the participants' preferences might reflect the concrete instantiations. It might also reflect general issues in fashion, as fashion is more than following simple rules. It has to do with what one is following, e.g. a person to admire, a desired brand or the latest trend. In this case we asked the participants to follow the aesthetic suggestions of a "machine", which might be less appealing than their current methods and explain why they preferred monochromatic matching. Second, it also indicates that we need to design for other approaches through which the digital device understands current outfit e.g. visual recognition. Some participants gave suggestions on how to get the color information of the clothes. Connecting the app to a digital wardrobe makes it easier for the users of that service to get the information, but for those who do not use that might require other methods to detect the color information. This requires more extensive collaborations between HCI and fashion design.

### 7.4 Customization vs Configuration

Finally, the study inspires to address a critical issue in the design of fashionable graphic interaction i.e. how much user control should be allowed to enable fashionable visual presentations. It has recently been argued that HCI could learn from fashion the importance of customization [31] that is allowing the user to change the appearance of a device. Since people dress up in different ways, then computer devices should not come with a standard design, or some automatic configuration, which is made up by professionals at an ICT company. It is suggested that it is in line with fashion to allow people making their own choices. The value of this learning is questionable for two reasons, First, allowing and support personalization, e.g. designing for user control of interface presentation [18], is already something of a hallmark in interaction design and HCI [26]. So this is not something that we have to learn from fashion. Second, and more important, although we acknowledge the significance in being able to vary visual aesthetics, we suggest that this idea of fashion is much too simplistic. In order to account for fashion in visual presentations on wearable screens we need to consider fashion theory [21]. It tells us that fashion is also a system of institutional arrangements that turn something into adorned objects [21] and that people become fashionable because they follow such "institutions" as brands, taste experts, celebrities, admired groups etc. An orientation to fashion requires to account for users' ambiguous demands to both follow others and at the same time express individuality. In order to generate fashionable graphic interaction on wearables, we need to allow some user control but also link visual presentations to supporting fashion institutions. In other words, we need to provide fashionable configurations of the graphic presentation. It might be that users would like the visual interface to reflect institutional taste generated by professional designers at H&M, Zara or Chanel, but not the design provided by ICT companies such as Samsung or Apple. We recognize that our design is agnostic in this sense, since it picks up color in worn items, independent of whether users by this selection is following an institution or attending to a very individualistic expression. And the color matching mechanism does not present trendy and contemporary suggestions either. However, it inspires to conceive of more explicit institutional/configurational design mechanisms in next generation of such fashion services, which could be done through clothing recommendation system discussed previously [18]. If the alternative colors are configured based on fashion trend analysis, it would be a more thorough institutional design approach than this initial version.

## 8 Conclusion

With the advent of wearable devices equipped with screens that are visible by co-present people, we argue for the need to apply fashion thinking in designing their visual expression. As an initial attempt to investigate this emerging design space, we followed a combination of methods including a fieldwork study of wristwatch wearers, a design instantiation and an initial user study. Our study contributes to the research of wearable technology both on a detailed level and on a general level. First, "Watch for Figuracy" was designed as an exemplar to investigate how to provide fashion "smartness" that is contextually dependent on the wearer's current outfit. We found support for the idea of designing applications for smart watches, which match the visual appearance of watch face to dressed ensembles. On a general level, the study articulates the need to account for visual aesthetic experiences in wearable design, and especially the need to consider use of the increased opportunities for graphic interaction on wearable displays. Such understanding of fashionable software would be applicable also to smart jewellery, e.g. the recent Swarovski Shine Misfit collection [47], and smart clothing.

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