What Makes You Click: Exploring Visual Signals to Entice Interaction on Public Displays

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ABSTRACT
Most studies take for granted the critical first steps that prelude interaction with a public display: awareness of the interactive affordances of the display, and enticement to interact. In this paper we investigate mechanisms for enticing interaction on public displays, and study the effectiveness of visual signals in overcoming the 'first click' problem. We combined 3 atomic visual elements (color/greyscale, animation/static, and icon/text) to form 8 visual signals that were deployed on 8 interactive public displays on a university campus for 8 days. Our findings show that text is more effective in enticing interaction than icons, color more than greyscale, and static signals are more effective than animated. Further, we identify gender differences in the effectiveness of these signals. Finally, we identify a behavior termed "display avoidance" that people exhibit with interactive public displays.

Author Keywords
Public displays; interaction; attracting attention; visual signals

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

General Terms
Human Factors; Design;

INTRODUCTION
The design of interactive public display studies often begins with an application or service that is deployed on a display. Researchers often implicitly assume that users have already discovered the display in question, somehow inferred that the display is interactive, and have become motivated enough to approach and touch the screen to begin interaction. However, these steps prior to the user committing to interaction are non-trivial and should not be taken for granted. The major challenges they entail are how to make passers-by aware of the interactive affordances of the display, and entice them to approach the device and begin interaction, i.e. overcome the 'first click' problem previously identified in [5, 14, 22].

CHI 2013, April 27–May 2, 2013, Paris, France.

This problem space breaks down to three separate phases. First, potential users must notice the display. In a cluttered environment such as a city center where multitudes of visual stimuli compete for attention, this is not trivial. The tendency of people to overlook displays, also known as display blindness, has been identified in previous research [13].

Second, potential users must be made to understand that the display in question is interactive. While interactive information kiosks and screens are becoming quite common in various spaces such as shopping malls, train stations or airports, most displays in public spaces are still used for passive one-way broadcasting of commercial or non-commercial information. Making the distinction between interactive and passive displays can be difficult, especially if both types exist in a shared space, and special care must be taken to ensure that people can easily tell the two apart. This phenomenon is called interaction blindness and has been documented in previous research [27].

Third, potential users must be persuaded to become active users [25]. Even if the first two barriers to interaction are overcome, a person may still choose to pass by a display without interacting with it. Therefore, the display must be able to communicate that it may possess something of value to the potential user [36]. This may vary from useful information to ways of killing time, depending on the context and the current needs of the user.

Despite the importance of these challenges, relatively little is known about the factors influencing motivation and inviting interaction [1] in the context of public interactive displays. In their Notification Collage study [10] Greenberg & Rounding found that co-present use of public displays rarely occurred, while remote usage flourished. Churchill et al. found that users tend to need "constant encouragement and demonstration" to interact with displays [6]. Similarly, Agamanolis [2] stated that "half the battle in designing an interactive situated or public display is designing how the display will invite interaction". Brignull & Rogers [4] recommended introducing novelty and ambiguity to draw users in, although they note that such an approach may prove to be a short-term solution due to the fact that once people become more experienced with interactive public displays, they are likely to become more wary, and may only be motivated to interact if the system can clearly communicate what it has to offer.

Müller et al. [26] noted that many displays fail to attract enough attention of passers-by because they vanish in the clutter of things in public space that compete for attention. In addition, even when displays manage to capture attention, they often fail to motivate passers-by to interact. Indeed, many displays fail to accommodate for the very public nature of interaction, a context where people may be hesitant to interact with such displays because they may be afraid of breaking the social code and perhaps looking silly [4, 27].

In this paper we investigate how different types of atomic visual elements, combined to form visual signals, contribute to enticing interaction on public displays. Here, we are interested in direct interaction, i.e. physically interacting with a public display by touching it. We contrast this objective with indirect interaction where, for instance, a person is not directly touching a display but interacting by, for example, performing bodily gestures to control a mirror image representation of self on a display, as suggested by e.g. [25]. We argue that physically touching a display can be seen as a 'stronger' form of interaction, as it requires a person to be very close and thus make a deeper commitment to interacting than playfully gesturing from a distance.

Here, we look at the effect of three distinct atomic visual elements on enticing direct interaction: color, motion, and graphic. We experiment with 8 'signals' or visual cues based on these three elements. The resulting signals were tested "in the wild" at a university campus in a field trial lasting 8 working days, using 8 identical touch-enabled displays placed in 8 locations around campus. Our objective is to understand which visual elements are most effective in i) capturing the attention and curiosity of passers-by, ii) enticing people to approach the display and iii) overcoming the "first click" problem previously identified with public information kiosks (cf. [5, 14, 22]), i.e. encouraging users to begin interacting with a public display. We focus on investigating the effectiveness of atomic visual elements and comparing them to each other, i.e. is color more effective than greyscale or is animation better than static?

It is important to note that we do not claim that results derived through studying our signals would be generalizable to any signal of similar nature: surely the design of an icon, or the wording of text will have an effect on the effectiveness of a signal. However, our study introduces a novel method for studying such visual signals, and is thus a valuable contribution in that other researchers may utilize the method and produce comparable results with different graphical designs, in different contexts and with different user demographics.

In this study we do not explicitly look at the effect of display location, as a university campus is a rather homogeneous setting with little variation in the nature of locations. However, when appropriate, location will be discussed in conjunction with other data. Further, we do not look at how the physical appearance of a display affects interaction, but rather focus on content shown on the screen.

RELATED WORK

People rarely seek public displays actively, but rather encounter them in a serendipitous manner [26]. After encountering such a display, people need to first understand that the display is interactive, and secondly be motivated to approach and touch the display. While the sharp rise of touch-enabled personal devices such as mobile phones and tablet computers has paved the way for a shift in the way people view display surfaces, the all-too-common mindset is still seeing a public display as a television, which you are not supposed to touch. This is known as interaction blindness [27], and refers to the fact that people do not realize that a display is touchable - most large display surfaces such as televisions or computer monitors require an additional device such as a remote controller or a mouse to interact.

Researchers have approached the problem of attracting attention and enticing interaction with public displays from various perspectives. Ju et al. [14] studied so called 'attract loops' in enticing users to interact with an information kiosk, and compared physical objects (a physical representation of a hand and an arrow) with similar digital content, i.e. virtual on-screen or projected representations of the same physical objects. They found that physical objects are more effective than virtual ones, and concluded that motion and physicality are significant influences on approachability and social engagement. Brignull and Rogers [4] recognized three distinct 'activity spaces' with their Opinionizer prototype, namely peripheral awareness activities where people only notice a display peripherally, but do not know much about it; focal awareness activities, where people engage in social activities associated with a display, such as talking about it or gesturing towards it; and direct interaction activities, where people actively interact with a display. Thus, people need to be encouraged to cross the different 'thresholds' from passive observation to active usage, and the display needs to provide a viewer with key information about its interactive affordances at first glance. Brignull and Rogers recommended positioning the display near traffic flows in order to ensure a steady stream of people from which to draw, and also using a 'helper', i.e. a person to initially guide people in using the display in order to attract the first few users who, in turn, will help attract subsequent users by their example, i.e. the honeypot effect [4].

Similarly, Vogel and Balakrishnan [36] identified four separate phases of interaction, namely ambient-, implicit-, subtle-, and personal interaction. They suggested that the display should transition from showing general content to more personal content, according to the proximity of users. They also suggested utilizing an abstract representation of the user on the screen in order to attract attention. A similar 'mirror' metaphor was used in the 'Magical Mirrors' prototype [23], where a mirror image of the audience, with added graphical elements such as ribbons following the users' hands, was used to attract attention. More recently, Müller et al. [25] took the 'mirror' metaphor further by deploying three displays for three weeks in shop windows in a city center. The displays showed either the mirror image of a user, a silhouette representation, or no image at all. The displays also rotated between showing an attract loop with a call to action ("step close to play"), or no attract loop. Content on all three displays was a simple game where users could move balls on the screen through bodily gestures. They found that a mirror image is more effective in enticing interaction than a silhouette or no image, and that no attract loop is more effective than a call to action.

Other metaphors used with public displays include the poster metaphor, where a display is seen as an electronically augmented counterpart of a traditional print-based poster [26]. Examples of using the poster metaphor include the CityWall deployment in Helsinki [28], and the Plasma Posters network [6]; the window metaphor which allows two or more displays to function as two-way windows between remote spaces (e.g. [24]); and the overlay metaphor, where digital content is superimposed on physical objects (cf. [30, 33]).

In summary, prior literature shows that the problems with inviting interaction on public displays are well documented. However, to our knowledge, no studies have empirically analyzed the effectiveness of atomic/composite visual signals in enticing interaction with public displays at such a detailed level as this study.

STUDY

Study Setup

To measure the effectiveness of visual signals in enticing interaction on public displays, we conducted a study of three visual elements, namely *color, motion, and graphic*. We systematically manipulated these to test their effectiveness in enticing interaction. Unlike prior work, we are interested in enticing direct as opposed to indirect interaction. We conducted an "in the wild" study for eight weekdays (ignoring the in-between weekend) using eight displays at eight locations on a university campus.

The following visual elements were selected for study: Color (color vs. greyscale); Motion (animated vs. static); and Graphic (icon vs. text). All eight combinations of these attributes were developed into signals, resulting in a 2x2x2 factorial design.

Eight displays (46" full-HD LCD panels with touchscreen overlay, figure 1) were placed throughout a university campus so that at least one display was located in or nearby the premises of every faculty on campus. In order to ensure a steady flow of people, the displays were positioned along busy walkways (i.e. main corridors), or nearby restaurants or cafeterias.

The 8 displays rotated the 8 signals daily according to a schedule, so that no two displays showed the same signal on the same day, and all displays showed all signals once during the 8-day period. This scheduling was implemented to account for the effect of location, i.e. make sure all signals were tested in all locations. All displays were powered constantly, and rotated signals automatically at midnight. During the weekend all displays showed an image wishing 'happy weekend', and no data was collected during those days.

When a passer-by touched a display, a short questionnaire with demographic information and 5 questions on a 5-point Likert scale was shown. The questionnaire served both as a data collection mechanism, but also as a plausible explanation for the purpose of the displays in the first place. The questionnaire captured the gender and age distribution of users, as they are otherwise anonymous. Once the user either submitted the questionnaire, or the display remained idle (i.e. no touch) for 60 seconds, the display reverted back to showing the active signal.

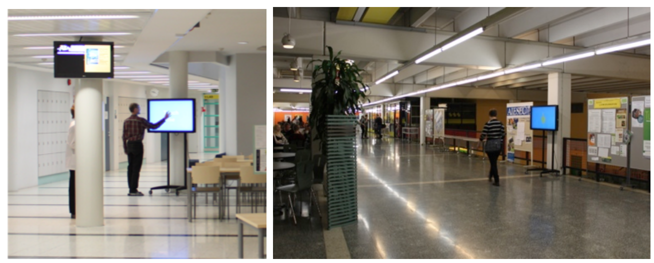

Figure 1 Displays #7 (left) and #4 (right)

We recorded the number of touches for each display during the study, along with the associated signal shown and when the touch took place. Further data was collected through unobtrusive observation (8 hours) and semi-structured interviews (n=32). These were conducted with members of the public immediately after they had either clearly passed by, or interacted with, a display. To reduce the likelihood of any bias, we approached the interviewees after they had walked away from the display in order not to obstruct the display and ensure that passers-by could not infer that people using the display were being interviewed.

Visual Signals

Our study used 8 signals, which are all the possible combinations of the three variables we manipulated: color, animation, and graphic.

Following recommendations from literature, we used yellow objects on a blue background (figure 2). For instance, in a study of 233 people from 22 different countries, Hallock [11] found that 35% of female respondents and 57% of male respondents (i.e. 42% of all respondents) named blue as their 'favourite' color. Marketing research shows that blue is often associated with trust and security, and used by e.g. formal restaurants to create a calming and relaxing atmosphere [15, 16, 17]. Yellow is associated with optimism and youth, and is often used to capture attention of window shoppers [16]. MacDonald [21] recommends using color combinations with high contrast such as black or blue on yellow, or vice versa, when designing graphics that need to both attract attention, and be legible at the same time. To preserve the contrast, greyscale signals were created by removing color (but maintaining contrast) instead of using black and white.

In selecting the icon to be used, several existing sets of icons designed for touchscreen devices were reviewed. Out of these, five icons representing 'touch' or 'tap' were selected as candidates. They were then evaluated in a small pre-study with 10 participants (5 male, 5 female) recruited randomly from the university campus. The icon selected for deployment (figure 2) was indicated as best describing 'touch' by 7 out of 10 participants. For the textual signals, the neutral phrase 'touch me' was selected, as we felt that including a strong call for action or emotional words such as "please" or "now" could introduce a bias.

For animated signals, we used a continuous anchored grow/shrink animation with both icon and text, as shown in figure 2. Previous research has shown that motion can trigger an orienting response attracting a user's attention even when appearing in the periphery of the visual field [8]. The human ability to perceive motion also declines much less towards the periphery of the visual field, as confirmed by Peterson and Dugas [29]. In their experiment, static targets were found to be virtually invisible in the far field whereas moving targets were easily detected. Other studies (cf. [12]), however, suggest that it is not motion per se that attracts attention, but rather the appearance of a new object in the visual field. The human visual system is capable of tracking up to 5 moving objects in parallel without context-switching, and when a new object gains the attention of the tracking system, an existing one will typically be lost [31]. Anchored motion was also perceived as less distracting than travelling motion by Bartram et al. [3].

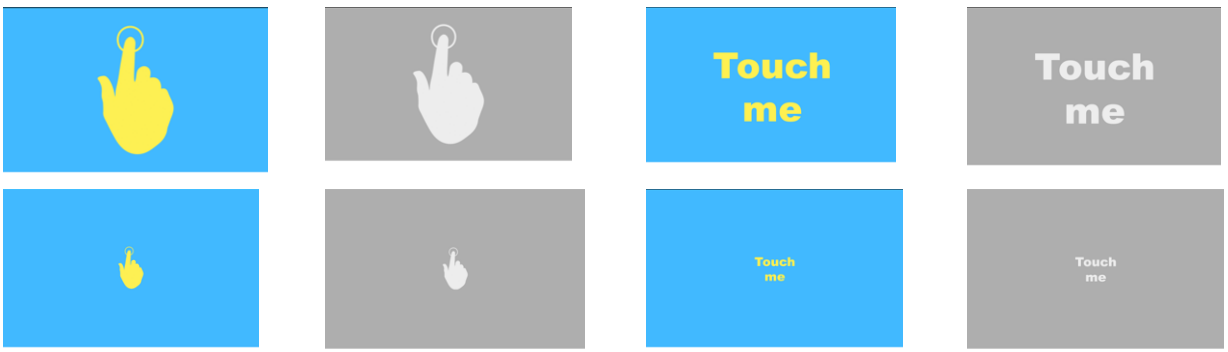

Figure 2 Signals used in the study. Top row: static signals at their maximum size relative to the screen size. Bottom row: the animated signals at their smallest relative size.

Signal	Touches	Disp1	Disp2	Disp3	Disp4	Disp5	Disp6	Disp7	Disp8	avg/day
1:C-A-I	179	46	10	37	24	7	14	18	23	22.4
2:C-A-T	301	53	90	43	33	10	14	35	23	37.6
3:C-S-I	197	26	37	64	15	18	5	23	9	24.6
4:C-S-T	279	31	24	62	91	7	11	38	15	34.9
5:G-A-I	134	26	6	23	35	8	6	26	4	16.7
6:G-A-T	277	24	4	31	65	35	66	37	15	34.6
7:G-S-I	197	18	14	24	35	21	17	62	6	24.6
8:G-S-T	299	23	18	58	25	27	23	74	51	37.4
Total	1863	247	203	342	323	133	156	313	146	29.1
Avg/signal	29.1	54.9	45.1	76.0	71.8	29.6	34.7	69.6	32.4	
Questionnaires	1101	130	114	200	173	91	101	198	94	
Male/female ratio (%)	60/40	83/17	66/34	78/22	67/33	54/46	53/47	35/65	34/66	

Table 1 Usage statistics per signal and per display. Legend: C=colored, G=greyscale A=animated, S=static, I=icon, T=text

Figure 2 shows the signals used in the study. For static icons, the maximum size of the animated signals is used (top row in figure 2). The bottom row shows the animated signals at their smallest scale.

RESULTS AND FINDINGS

No participants were recruited for this study. All people who interacted with the displays did so on their own will, without being briefed or otherwise motivated by researchers, fliers, or email announcements. Over the period of eight days, a total of 1863 touches (29 daily touches per display), on all displays were recorded, when only the first touch to signal was counted, not subsequent touches to fill in the questionnaire. Out of these, 1101 (59 %) led to the submission of a questionnaire. Table 1 summarizes touches per display and per signal.

Effect of Signal on Number of Interactions

As shown in table 1, signal #2, i.e. colored animated text (C-A-T) attracted the most interactions (301), with signal #8 (G-S-T) following just behind with 299 touches. Signal #5 (G-A-I) attracted the least number of touches (total 134), and signal #1 (C-A-I) the second least with 179 touches. Overall, signals with text were more effective than signals with icons. Interestingly, in terms of total number of interactions, there was no clear difference between colored and greyscale variations of the same signals.

The nature of our study makes the use of statistical tests challenging. In order to identify the effect of signals on enticing interaction and their possible interaction effects, we ran a 3-way ANOVA. Due to the "in-the-wild" nature of our study we have no way of identifying individual users, and therefore considering each touch as an independent trial is likely to lead to spurious results. Instead we chose to adopt the most conservative approach to analyzing the data, which treats the entire potential user population as a single entity. Hence, we assume that our study produced a single "rating" for each condition, a rating that took 8 days to establish. In this sense we treat the whole study as a single trial lasting 8 days, and all people on campus as a single entity. This is a much weaker assumption than assuming independent trials for each data point in our study, and is thus the lesser of two evils as there are no statistical tools designed for the conditions of our particular analysis.

Not taking display location into account, i.e. only looking at the variance of touches for different signals, we found a significant effect for all visual attributes: Color vs. Greyscale $F(1,1) = 2401$, $p<0.05$; Animated vs. Static $F(1,1 = 6561$, $p<0.05$; Icon vs. Text $F(1,1) = 201601$, $p<0.05$. We also found significant interaction effects for combinations of attributes as follows: Color and Motion $F(1,1) = 7921$, $p<0.05$; Motion and Graphic $F(1,1) = 6561$, $p<0.05$; and Color and Graphic $F(1,1) = 1681$, $p<0.05$. Figure 3 illustrates these interaction effects.

Due to the unreliable nature of our statistical analysis, we also rely on secondary measure. In particular, we consider the estimated marginal means per condition in our study. In figure 3 we observe a main interaction effect between Color and Animation, and the subsequent breakdown for text and icon. This analysis shows that i) for greyscale text, a static signal is more effective than animated; ii) for colored text, the opposite holds true: an animated signal is more effective than static; iii) for both greyscale and colored icon, static signals are more effective than animated, although with colored icons, the difference is less pronounced than with greyscale icons.

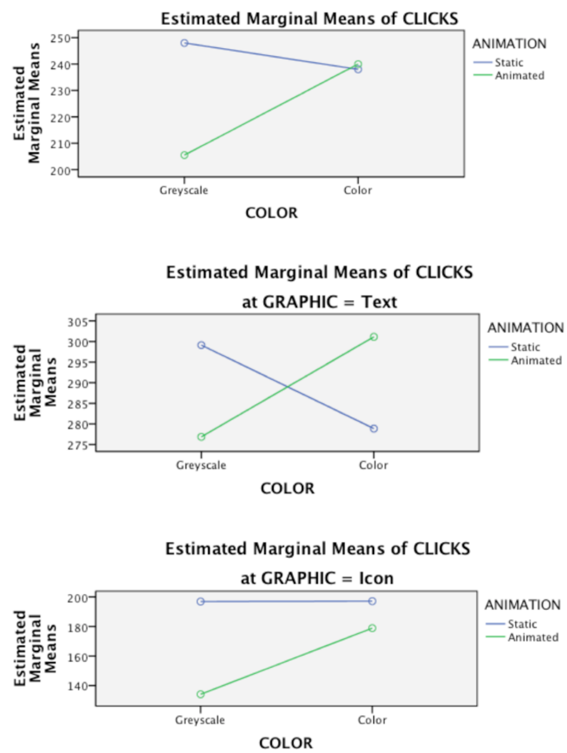

Figure 3 Top: main interaction effect of color and animation. Middle: breakdown for text. Bottom: breakdown for icon.

Effect of Gender

While we have no way of identifying users, gender preferences can be derived by considering the number of touches in relation to the questionnaire responses for gender. This analysis revealed an interesting dichotomy between genders. Men (i.e. respondents who reported 'male' as their gender in a submitted questionnaire) were mostly enticed by *color* and *animation* - signal #2 (C-A-T) registered the highest percentage of 15.98% of all touches by men. Conversely, women were mostly enticed by *greyscale* and *static* – signal #8 (G-S-T) registered 20.63% of all touches made by women. Overall, men were more responsive to signals with *color* while women to signals that were *greyscale*. Both genders responded more to *static* over *animated,* and women responded more to *text* that *icon*, while for men vice versa. Figure 4 illustrates these gender differences.

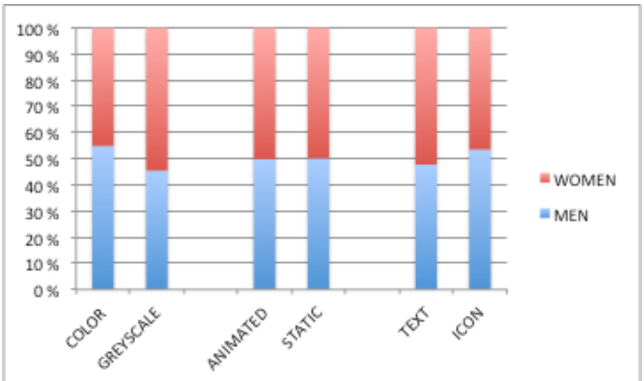

Figure 4. Gender differences with atomic visual elements.

Effect of Location

Our data showed a significant variance in number of touches between locations (=displays) ($F(7,56) = 2.463$, $p<0.05$). Because of this finding we ran a one-way ANOVA to verify whether the type of signal had an effect on the number of interactions with regards to location (using the statistical assumptions we previously discussed). The ANOVA showed that besides location, only Graphic (i.e. *icon* vs. *text*) had a significant effect on the number of interactions ($F(15,48) = 3150$, $p<0.05$).

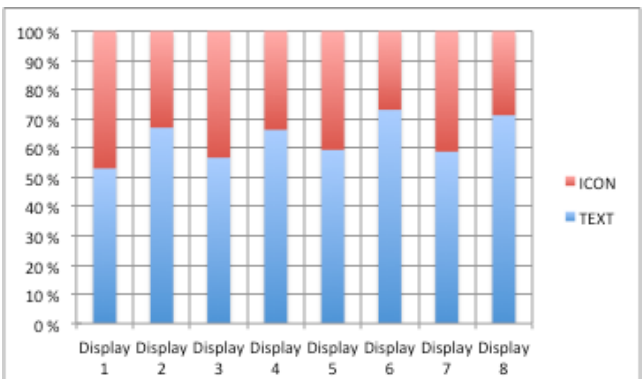

Figure 5 Breakdown of the number of interactions for 'text' and 'icon'

When looking at percentages of the number of interactions with all signals containing the attribute *text* and all signals containing the attribute *icon*, we see that *text* gathered a higher percentage of interactions across all displays (figure 5). However, with displays #6 and #8 the difference is highly pronounced, with 46% and 43%, respectively (i.e. display #6 gathered 46% and display #8 42% more touches to signals with text than to signals with icon).

Gender preferences regarding *text* and *icon* might again explain this finding, as displays #6 was located in a cafeteria at the faculty of humanities, and #8 in a cafeteria at the faculty of education, both of which have a predominantly female body of students. Thus, we speculate that we might actually be seeing an effect of *faculty*, and not location *per se*. Since display location was not a controlled variable in the study, this phenomenon requires further research to understand.

Observation and Interview Data

We conducted 8 hours of observations during the study, i.e. one hour every day. Altogether we manually observed 180 interactions with the displays during the study. In addition to direct touches to the display, we also observed glances, gestures, and other indirect interactions, as well as the social context in which the interaction took place (i.e. alone, in a group, hurrying, etc.). Most glances were short, lasting only for a couple of seconds, which is in line with previous research [13]. However, several times a group of two or more people would notice a display, stop, and discuss the display before approaching it and beginning interaction. Similarly, we noticed people touching a display, becoming disinterested once they noticed that the only content was a questionnaire, and walking away. In some cases a second unrelated person would pass by the display within a few seconds, notice the questionnaire still visible, and fill it in. The 'honeypot' effect [4] was also clear, and we observed several occasions where a person interacting with a display clearly caught the attention and curiosity of others who, in turn, then started interacting with the display.

In contrast to the honeypot effect, we also observed people actively ignoring the displays. This behavior became strikingly obvious, as it was repeated nearly every day during observation. For instance, this was observed at display #4 located on a busy thoroughfare opening to a cafeteria on one side, and having a view to a downstairs restaurant on the other (figure 1, right). The display here was sandwiched between two bulleting boards showing paper-based signage such as event information and a large ad for student exchange programs

Often, people walking in either direction would have their head turned towards the bulleting boards and appeared to be reading the notices. When they noticed the display, however, they would quickly turn their head in the other direction, and then turn back once they had passed the display. We term this behavior *display avoidance*. When interviewed about this behavior, one person described his reason for avoiding the display as follows: "The campus is so full of these information displays that I never look at them anymore – the massive information overload is just too much to handle". Other respondents gave similar, if not as pronounced, explanations as well.

Furthermore, we conducted 32 (14 male, 18 female) semi-structured interviews in various locations around campus. We wanted to better understand how people perceived the displays, and whether or not they had noticed them around campus in the first place. We also inquired if they could remember what was shown on the display they had just passed, whether they had interacted with any of our displays and why (not), and which type of content they felt would best attract them to approach and touch a display. Lastly, we asked the respondents to indicate which visual attributes they felt would work best at attracting them to interact with a display (i.e. colored or greyscale, animated or static, image or text).

Interviewees were selected on-opportunity basis, and interviewers positioned themselves nearby displays so that people had clearly passed by a display but could not make out what was shown on the screen. A majority of respondents (23) said they had noticed the display they had just passed, and 17 of these said they remembered what was shown on the display, with about half actually remembering the correct signal and others responding with signals shown on other displays. Several respondents also proceeded to list other visual signals they had encountered with other displays. Ten respondents said they had interacted with one of the displays, and out of these, 8 named curiosity as one of the main reasons for doing so. Similarly, 4 respondents explicitly identified the 'touch me' text as the main motivator for interacting. Regarding content that respondents thought would work best in enticing them to interact with a display, topical and informative content types such as public transportation schedules, recent news items, and information about upcoming lectures and other events around campus were mentioned the most often. Not everyone felt positively about the displays, however. On three separate occasions, female interviewees said they had noticed the displays but had not touched one, and were not going to because they were afraid of "breaking" it.

When participants were asked to make a binary choice between visual attributes they thought would attract them to interact with a public display, *color* was selected over *greyscale* (28 vs. 4), *animated* over *static* (21 vs. 11) and *icon* over *text* (25 vs. 7). A Chi-square analysis revealed a significant effect for gender on preference regarding *color*, with $x^2(1, N=32) = 5.878$, $p<0.05$. However, 100% of interviewed women selected *color* over *greyscale*, which is the opposite of what data on actual usage shows. Further, 79% of men and 78% of women selected *icon* over *text*, again showing the discrepancy between *a priori* expectations and *a posteriori* behavior with regards to visual signal enticement. This phenomenon has also been identified in [19].

Questionnaire Data

The questionnaire displayed after the initial touch to a signal consisted of demographic information (gender and age group), and five statements on a 5-point Likert scale (5 = completely agree … 1=completely disagree). Submitting an incomplete questionnaire was allowed. Altogether 1101 questionnaires were submitted, with 944 containing gender information. Out of these, 562 were submitted by men (60%) and 382 by women (40%). Table 1 summarizes the number of submitted questionnaires and gender variation per display. As is to be expected in a campus environment, a majority (76%) of respondents were aged between 18 and 31.

Chi-square tests showed that neither signal nor display location had a significant effect on questionnaire responses. However, gender had a significant effect on replies to statements 3 ("the display caught my attention") and 4 ("I like playing around with technical gadgets"). Women reported the displays catching their attention (S3) more than men (men: avg 4.33 stdev 1.052, women: avg 4.47 stdev 1.046) with $x^2(4, N = 924) = 15.834$, $p = 0.003$. While the statement might seem counterintuitive (after all, the respondent had to have noticed the display prior to filling in the questionnaire), we wanted to gauge and compare the users' self-perceived efficiency of the different signals through this statement, i.e. see if people reported differences in how different signals caught their attention. Also, perhaps not surprisingly, men reported liking technical gadgets (S4) more than women (men: avg 4.22 stdev 1.161, women: avg 3.12 stdev 1.471) with $x^2(4, N=920) = 141.979$, $p=0.000$. With this statement we wanted to see if technophiles would react differently to different signals, but found no significant results to support this.

DISCUSSION

This study was designed to be a 'first thrust' in systematically measuring the effect of various atomic visual elements on enticing interaction on public displays. In previous studies, various methods for enticing interaction have been tried, but these have been *ad hoc* in nature, as the main focus is often on studying an application or service that is made available *after* users make the first click/touch and enter interactive mode, and not the attract sequence itself. Not understanding how various visual elements attract attention may lead to a situation where the visual cue meant to entice interaction actually becomes detrimental to its purpose. For example, in their study of an interactive information kiosk [34], the authors found that their flashy, animated 'attract loop' failed to attract people to use their system since passers-by rather adopted the role of passive observers watching the attract loop than becoming active users. Similarly, an attract sequence with a moving head avatar meant to entice interaction stole attention away from the actual system, as described in [7]. Thus, it is crucially important for designers of interactive public displays to understand how to design visual signals that not only attract attention, but also invite interaction.

In addition, an important aspect of our work is that we focus on *direct* rather than *indirect* interaction. While a lot of work has previously looked at how dynamic animations and graphics can make users "play" with a display using hand and body gestures, we argue that this is a weaker type of interaction focused on opportunistic playfulness and enjoyment. On the other hand, enticing users to walk up to a display and touch it is challenging. For instance, some of our interviewees claimed to actually be afraid of doing because of a fear of "breaking" the display, a finding which has also been made with other interactive public display studies (cf. [27]). For this reason we argue that direct and explicit interaction is a stronger and more meaningful action, as it requires overcoming psychological and social barriers, at least for some people.

Clearly, however, our study has only considered a limited set of visual signals. As such it is hard to make assumptions about other types of possible signals, such as signals that incorporate video and sound that were left out intentionally in this work in order to keep the study design coherent. However, our systematic manipulation of atomic visual elements such as color or motion gives us insight into their relative effectiveness, as we describe next.

Understanding Visual Signals

The analyzed data showed that the most effective signal in terms of total number of interactions was *colored animated text*. For signals with *text*, *color* was more effective when the text was *animated*, while *greyscale* was more effective when the text was *static*. Conversely, signals with icons were equally effective regardless of color or greyscale, but static icons were better than animated.

We expected *color* to be more effective than *greyscale* since previous work has shown color is more likely to evoke and distill emotion [15, 16, 17]. Similarly, we expected *animated* cues to be more effective than *static* ones because motion can be more effective at capturing people's attention [8]. In this respect, it has been a very interesting finding to identify *text* as more effective than *icon*.

Regarding *text* and *icon,* it is challenging to make a reliable comparison – it is probable that the selection of words and the design of icon impact the effectiveness of such signals. In the study we selected 2 representations, i.e. an icon and a string of text, both meant to convey the message "touch this display". These were systematically manipulated by making them either grayscale or colored, animated or static. We do not claim that the icon or the text represent all possible icons, or any piece of text, but rather state that for the 2 given representations, we identify which manipulation is more effective. Thus, one contribution of this paper is the methodology for identifying which of the representations is more effective. We use our methodology to compare 8 signals in our study, and describe it in enough detail so that the experiment is replicable.

It is clear that multiple design alternatives are possible for enticing interaction with a public display. Our work has only begun to unpack this domain, and indeed it raises many new questions. We hope that other researchers may use our method to test their own visual cues, and produce comparable results to evaluate the effect of different wording, different icon design, different colors, etc.

Implications for Research: Designing for Attraction

Public displays, by their very nature, are highly public artifacts and thus differ from other computers such as laptops, smartphones, or tablets that are user customizable, meaning that people may alter the appearance of their devices and applications running on those devices (i.e. "skinning") to fit and mirror their personality and taste. This option is not available on public displays, which are owned by an organization of some kind, be it university or a business, and altering the device in any way is likely to be considered vandalism. Aesthetic design has been shown to affect our first impressions of objects, and these first impressions often color the way in which we perceive those objects. Thus, the design of attractors on public display will set the tone for people's experiences with them [35].

The visual signals explored in this study help shed light on the types of visual elements that encourage people to approach and engage with public displays; variations of these atomic visual elements can then be used by other designers and researchers to enhance the experience of people encountering such displays for the first time. Our study uncovered an interesting issue related to the gender differences that go against established stereotypes (stereotypically, women are thought to like colorful things [18], etc.). Our data shows that women prefer *greyscale* to *color* and *static* over *animated,* whereas men preferred *color* to *greyscale* and *icon* over *text*. In interviews, though, women still clearly chose *color* and *animation* over their counterparts. This discrepancy may be due to the *researcher effect* [20], but along with data on actual usage highlighting differences in the way signals with certain visual elements appear to be more attractive to one gender than the other, this is a novel and interesting finding that merits further research on the subject.

Display Avoidance

Huang and Borchers [13] found that using physical items nearby a display may help draw the attention of passers-by to the display itself, but only if the items in question come to the attention of a person before passing a display. We observed a similar behavior, where people became interested in unrelated items nearby our displays, and subsequently also glanced at the display. However, the emergent behavior we observed of people actively *not* looking directly at the display after noticing it, i.e. *display avoidance*, is of particular interest.

To explain this behavior, we draw on social actor theory [9, 32]. It suggests that unacquainted people generally tend to actively avoid face engagement with one another in public spaces. Such "civil inattention" is not considered rude, but rather polite behavior. Drawing on this work, Ju and Sirkin [14] hypothesized that just as it is more acceptable to make eye contact with certain people such as receptionists and sales clerks who work in "exposed" roles, public displays with certain physical locations or even orientations are "exposed", thus providing permission for unacquainted engagement. Hence, selecting locations where the display is properly exposed can have a significant effect on enticing interaction.

Therefore, we hypothesize that certain locations are more "available" or "exposed" than others, thus making interaction with these displays in these spaces more socially acceptable. Conversely, some locations, by nature, do not invite or encourage interaction. It is still not clear to what extent this is generalizable across gender/age/social groups. For instance, do children have inhibitions towards interacting with public displays in locations where adults would feel uncomfortable? It is also unclear what are the characteristics that make a space and display "available" or "exposed". Further, returning to the point of designing public displays for aesthetic experience, can the appearance of a display itself make it more "available", and if so, what would the visual characteristics of an "available" display be?

Limitations

We fully acknowledge that our particular use of statistics in the analysis may be questionable. Due to the "in-the-wild" setting of the study, and our lack of control over participants, it becomes challenging to identify tests that are robust to these conditions. For this reason we have actively chosen to adopt the most conservative approach to our statistical analysis, and further complement it with a more simplistic analysis using estimates of marginal means. The lack of appropriate analysis techniques for uncontrolled environments is an important obstacle in conducting reliable studies in such settings.

Further, our field trial took place on a university campus, which narrows the user demographic down to a rather homogeneous group of college students and staff. Therefore we cannot make claims as to how well our findings would generalize in a more varied setting. Finally, 8 days is a short time, and the effect of novelty cannot reliably be estimated based on this data. We expect that since no other content besides the questionnaire was offered, people would quickly stop using the displays regardless of signal, unless more meaningful content was provided after the first touch.

CONCLUSION

In this paper we presented a study that assessed the effectiveness of three atomic visual elements, color, motion, and graphic, on enticing direct interaction with public displays. Unlike previous work considering indirect interaction through bodily gestures, our work focuses on explicit touch-driven interactions. Our findings suggest that people indeed have a number of inhibitions in terms of physically touching a display, and for this reason we argue that this type of direct and explicit interaction requires a more substantial commitment from users.

Our findings show that text is more effective in enticing interaction than icons, color is more effective than greyscale, and static signals are more effective than animated signals. We also identified gender differences in the types of visual elements that best attract attention and invite interaction. Furthermore, our study identified a distinct behavioral pattern: *display avoidance*. Display avoidance refers to people actively looking away from a display even when they are at arms' length from it, mainly in order to avoid information overload.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge financial support from the Academy of Finland, the City of Oulu, and the UBI (Urban Interactions) consortium.

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