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# Things of the Internet (Tol): Physicalization of Notification Data

**Kieran Woodward**

Nottingham Trent University  
Nottingham, UK  
Kieran.woodward@ntu.ac.uk

**Eiman Kanjo**

Nottingham Trent University  
Nottingham, UK  
Eiman.kanjo@ntu.ac.uk

**Abstract**

When it comes to attention and notification management, most of the previous attempts to visualise notifications and smartphone usage have focused on digital representations on screens that are not fully embedded in the users' environment. Today, the constant development in hardware and embedded systems including mini displays, LEDs, actuators as well as digital fabrication, have begun to provide new opportunities for representing data physically in surrounding environments. In this paper, we introduce a new way of visualising notification data using physical representations that are deeply integrated within the physical space and everyday objects. Based on our preliminary design and prototypes, we identify a variety of design challenges for embedded data representation, and suggest opportunities for future research.

**Author Keywords**

Data physicalization; Emotion Recognition; Notifications; Smartphone overuse; Attention management solution; smart home.

**ACM Classification Keywords**

Keywords J.4 Social and Behavioural Sciences.

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## Introduction

Notification and smartphone management have received a considerable level of attention in the past few years, with many interventions and solutions being proposed to help attention management. Most of these attempts have focused on smartphone applications that capture changes in phone use and use AI algorithms to model user attention levels or emotions [6, 9, 16].

This modelling capability enables the management of interruptibility, which in turns tackles attachment to smartphones and delivers attention management solutions based on the user's behaviour and interaction patterns with their smartphone.

On the other hand, technologies such as the Internet of Things (IoT) are often used to generate data that can then be visualised on a computer or a portable device with a screen. However, too much emphasis is put on the sensing and movement capabilities of these devices and less on shape-changing displays which utilise the latest developments in actuation and lighting technologies to physically represent data.

By merging the main effective characteristics of the two concepts together, we could develop an effective shape-changing interface to visualise and manage attachment to smartphone notifications.

In this paper, we propose a new concept called "The Things of the Internet"; a technique to represent notification data in order to help manage attention and reduce excessive smart phone usage while keeping the user informed of their emotion in relation to their online activities and notifications in a visual and artistic form.

The idea is to utilise lighting and actuation techniques to generate movement in shape-changing displays with physically reconfigurable geometry.

## SMART PHONE NOTIFICATION MANAGEMENT

Problematic smartphone use can affect majority of the population as many smartphone apps function as rewards that can lead to a habitual checking behaviour [8]. This habitual behaviour includes unintended consequences such as continually unlocking a phone to check for new notifications [18].

Also, research has shown a direct link between emotions and the level of engagement with smartphone notifications [10]. Recent research found that people with a low level of education, and students, are more likely to become addicted to their smartphones [11]. Thus, those most prone to excessive smartphone use impacting daily life are those aged between 16 and 24, who either have a low level of education or are still studying.

Problematic smartphone use is not just an important issue because of the vast amount of people it can affect but also because of the adversity and problems it can cause. For example, addicted students are less likely to achieve high grades [5]. As 16-24 year olds use their phones the most this could have a major negative impact on many students' academic performance.

It is not only psychological issues that can arise from problematic smartphone overuse; it can also lead to physical issues such as fatigue or lack of sleep [12]. Therefore, many attempts have been made to model and organise notification delivery in order to manage attention.

One attempt to manage notification delivery involved a device capable of forwarding notifications to other smart

devices such as a monitor or lights [17]. However, there was a large focus on forwarding all notifications possibly resulting in additional smartphone use as users are repeatedly interrupted to be made aware of new notifications.

Attention management solutions balance an individual's need for fewer disruptions while providing efficient information delivery [2], which is what ToI provides.

### THE THINGS OF THE INTERNET

Data physicalization is where a device's geometry or material properties encode data compared to traditional visualisations that map data to pixels. Examples of situated and embedded data representations have been independently explored in a variety of research areas, including information visualization, augmented reality, and ubiquitous computing which help increase visual realism.

Also, with the advancement of affective computing research [7, 20], many innovative prototypes are emerging. Lovers Cups [4] is one such example that comprises of two light-up glasses that remotely activate when a partner uses their cup to simulate drinking together. Each person can see in their cup how much liquid is in their partner's cup, when they are drinking and the side they are drinking from through visual feedback showing communication can be extended to daily interactions.

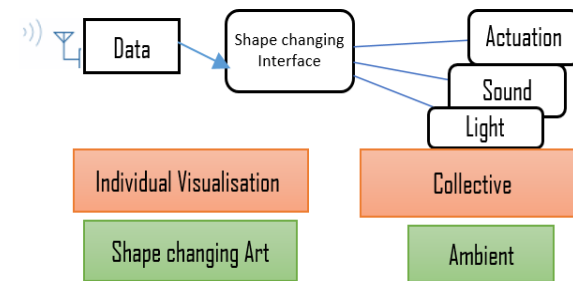
Several research prototypes have explored actuation using electro-mechanical motors [13], Servomotor [19], Shape-Memory Alloy (SMA) wires [14] and electromagnets [15] but no research has been conducted utilising this to physicalize smartphone use.

### SYSTEM DESIGN

We define the Things of the Internet for notification management as follows:

1. Receives stream of digital data from smartphone.
2. Relays information using some form of actuation, lights, sound, and/or any other form of feedback.
3. Dynamically manages user attachment to smartphones without extra disruptions.

Figure 1 shows the proposed framework for ToI including how data will be wirelessly transmitted before being processed on-device to produce varying shapes, sounds and colours.



**Figure 1.** Overview of (ToI) system for Notification Awareness

ToI does present some design challenges, as the technology must seamlessly blend in with other household items. To accomplish this the technology utilised must be small yet sufficiently powerful to handle the processing of incoming data.

ToI enables individuals with smartphone dependency to observe their mood visualised physically which could increase their awareness of the time they spend and consequences of their smartphone usage and its impact on wellbeing. To realise our vision for ToI, we have developed two preliminary prototypes that predict and

visualise mood using the emotion model developed in [9]:

**Prototype 1:** Visualises the mood of a few individuals at the same time (in this case three), each flowers in the vase move up or down according to the mood of an individual (see figure 2). To accomplish this data from the users' smartphones and wearables including notification data, phone use and physiological data (if present) is wirelessly transmitted to the prototype in real-time. The data received is then processed using the microcontroller powering the prototype; the happier the user is perceived the higher the flower moves in the vase.

This prototype does not provide large amounts of information to the users such as whether they have unread notifications but this makes the device 'glanceable'. In addition, the ability for it to display data from multiple users makes it ideal for families as it allows parents to easily monitor the impact their children's smartphone use is having on their emotional wellbeing.

This prototype possesses some design challenges, as it may be difficult to notice slight height differences over time making it hard to gain any meaningful insights. Additionally, when used with families it may be difficult to distinguish between the different flowers representing different people.

**Prototype 2:** Physically visualises the mood of an individual on a wall art frame for the individual and family to see.

An actuated surface with lines and squares forms patterns similar to the famous compositions shown in figure 3. Each line has a motor that allows it to move horizontally and vertically and the squares can be lit up

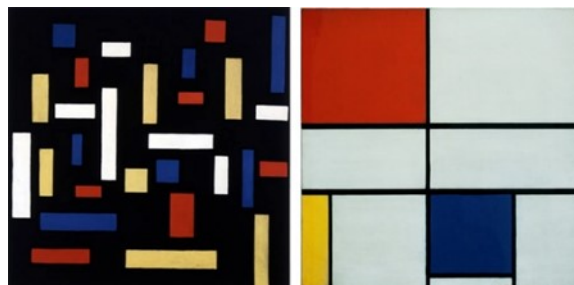
with different colours using a set of LEDs. These lines and squares allow for a wide array of patterns to be constructed all indicating different smartphone use and emotions.

Research has shown informative art can be an appropriate way to visualise data [3]. My painting shows my stats [1] demonstrated this by having a painting dynamically change in accordance with users' physical activity. This device was capable of conveying a large amount of information in a glance, as this prototype hopes to achieve.

While this prototype is capable of displaying more data than prototype 1 allowing users to know the current state of their smartphone and the impact it is having on their emotions, it requires more attention to understand the visual representations. This makes the design of this prototype difficult, as the amount of information displayed must be carefully balanced with its simplicity to ensure it is effective.



**Figure 2.** Overview of (TOI) prototype 1.



**Figure 3.** Left: Theo van Doesburg – Composition VII , 1917 / Right: Piet Mondrian – Composition C (no.III), with Red, Yellow and Blue, 1935. Both artists were a part of De Stijl movement in the Netherlands.

The two prototypes discussed both enable users to quickly glance at physical objects to understand how their current smartphone use is affecting their emotional state. By utilising common household items such as flowers and wall art, these prototypes inconspicuously help prevent the habitual checking of smartphones, improving mood and reducing the possibility of users becoming addicted to their smartphone.

In the future, we aim to evaluate these works based on the simplicity of the displayed information and the amount of information they manage to convey. Ideally, devices should be able to display all vital information including the emotional impact current smartphone use is having in a simple glance.

This initial work on notification management is limited to displaying the emotions of individuals to provoke contemplation of excess smartphone use and its impact on mood. Our intention for future work is to go beyond displays to more effective changes in ambient settings in order to promote behaviour change and ease attachment to smartphones.

## CONCLUSION

ToI is an early and conceptual interactive prototype that allows us to imagine and propose future interfaces. With the development of inexpensive, lightweight, energy-efficient actuator technologies we anticipate the development of thin, fast and effective shaped displays. These displays could be used every day as abstract and computational geometric art to physically visualise the dynamic flow of notifications, online activities and its impact on emotional wellbeing in an adaptive and personalised fashion. The next stages of this project will be to deploy these prototypes and evaluate their performance in real world settings. Also, we aim to go beyond displays and visualisations to implement some effective techniques to motivate users in changing their behaviour and reducing smartphone overuse.

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