Physicality in hybrid products

The role of physicality when data, services and new social meanings merge

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ABSTRACT

This paper explores the role of the physical components in interactive devices when data, networks, services and new social meanings merge into Hybrid Products. In this context the role of physicality from a product design point of view is being investigated through literature research, investigative prototyping and design research. While the physical world is rich and has a depth and legibility that digital technology envies –in a design context– physicality also forces us to prioritize. The physical component needs to be *dedicated but adoptive*. It is claimed, by giving examples, that the "dedicatedness" of a hybrid product has value for the user as long as the product has a sustainable amount of flexibility incorporated. It is also argued that physicality is good at narratives and emotions, two important elements when trying to make data useful and graspable for humans. When making these new products, successful implementation of physicality is when the tangible interface becomes an embodied and native part of the product.

KEYWORDS: hybrid products, tangible embodied interaction, Internet of Things, product design, physicality, ubiquitous computing

1. INTRODUCTION

In the last ten to fifteen years there has been a rapid growth of domestic products that have embedded electronics and connectivity. As objects become part of systems and services, the characteristics of these objects change, and a set of new dilemmas and challenges rise in our interaction with and use of these products. Especially the expansion of digital infrastructure and mobile devices has gained the actuality of connecting objects to each other in the same way as computers. Although these new products are increasingly referred to as The Internet of Things (IoT) in public media, there are a wide set of professions and perspectives with quite blurry distinctions related to it.

In this article the term Hybrid products (hybrids), as introduced by Jørn Knutsen et al. (Knutsen et al. 2011) is used. The term Hybrid products emphasise products that are made with a designerly approach, not solely focusing on the technology/opportunity-driven possibilities often seen with IoT-products. When Knutsen et al. suggested the term they focus on the interplay of digital and physical materials (Knutsen et al. 2011) and the connection between a physical device and digital networks (Knutsen et al. 2011). Their scope is to discuss the merging of product, interaction and service design and the relationship between humans, products and the Internet (Knutsen et al. 2011). In this article their paper acts as a foundation and context for the discussion of the particularities of the *physical component* of a hybrid product. *Physicality* is

used to emphasise the ecological quality of these components rather than a focus on their mechanistic properties. In the narrowest definition, physicality could be tangible objects or bodies, and the spatial relation between these objects and us (Hornecker 2009). In a slightly wider definition of the term, non-material phenomena like movement, sound and vision should be included. Going even broader, physicality also refers to a mix of our senses, our body and its activities, and to some degree our emotional state as it is expressed with sweat, tears, shaking, posture and so on. Physicality is also connected with our cognition (Dix 2006), and understanding physicality is focus for several design researchers (Ramduny-Ellis et al. 2010) (Hare et al. 2009). In this article, physicality represents the located body, the tangibility and materiality of the hybrid product.

IoT focuses on sensors and new ways of controlling and gathering data. However, there is an increased need for research on actuation and physical representation of data. How, and with what implications, can networked data be actuated and represented physically in a legible way?

Much of today's interaction research has its roots from the work at MIT Media Lab in the late 90's. With their paper on "digital Bits and Tangible Atoms" (Ishii & Ullmer 1997), Ishii and Ulmer became, among others, initiators of a quest for re-joining the richness of the physical world into human-computer-interaction (HCI). They state how graphical user interfaces (GUI) have failed to meet the rich skills and senses humans has developed over time.

While we today gain digital skills from childhood, we still have a broader more intuitive interaction with the physical world around us.

Today the versatility of touch screens has made them dominant as the new favourite interaction media in the consumer-electronic segment. Touch interfaces have pushed aside the focus on more tangible and dedicated experiences. But as electronics become cheaper and access points spread, new and more tangible and dedicated products are starting to reach the market. Some even claim that "hardware is becoming the new software" (Bilton & Markoff, 2012), referring to the possibilities of rapid development and small scale production obtain by additive manufacturing (Leader 2012). This trend might give possibilities to a new push in the need of more physical experiences as well as understanding the relationship between the physical component of the (hybrid) product and the digital counterpart.

1.1 Method

Literature from a wide set of research areas and sources has been reviewed. Much of the recent thinking on hybrids is yet to be found in scientific articles, and several of the sources are from articles on the Web. The goal of the information gathering has been to find the main inspirational sources for designers and researchers working with hybrids. Literature on Internet of things, hybrid products, interaction design and tangible embodied interaction is reviewed to search for the priorities and meaningfulness in the design of hybrid products. Further, particularly insights on the role, strengths and weaknesses the physical component has in a hybrid product are considered. This article has a set of key sources and inspirations:

- Eva Hornecker and Djajadinigrat on TEI
- Timo Arnall: both connected with Arkitektur- og designhøyskolen (AHO) in Oslo, and Berg London.
- Mike Kuniavsky, with his book Smart Things, have influenced many of the cited papers/people.

Complementary to writing this article I have done an investigative design project, surrounding the key themes in this article. The project concluded in seven interviews where reactions and possible

opportunity were discussed. Findings presented in the discussion.

2. HYBRID PRODUCTS & IoT

Hybrids, connected objects, smart objects, Internet of everything. Many terms are being used about these products, systems and services. IoT is the most common term, whereby an introduction as well as a background for the term hybrid products is presented.

2.1 Internet of Things

At The International Consumer Electronics Show (CES) 2013 IoT reached a new level of attention including mass media review. Especially in the context of consumer products everything is to be connected and gather data. Although we have been living in a 'connected' world, with lots of embedded sensors and actuators (visa cards, metro card, toll-pass, NFC/WIFI, toys) there is an increased interest in bringing the Internet out in the physical world (and visa versa) (Lohr 2011).

As the price of machine-to-machine communication technology (M2M) decreases, many expect a long anticipated boom of everything being connected, and the implementation of sensors and automation long seen in industrial applications. This trend has been much about sensors (quantified self, Shine, Nike,) and the computation of "big data". The first commercial projects like the Nike+ (now FuelBand) were brought to life, not so much because of hardware possibilities, but because we had phones acting as "hubs" (Yared 2013). New GUI patterns developed through a user experience boom connected with the launch of touch phones that were good enough to communicate and personalise this new information. The social factor is also important. The possibilities in sharing through digital services, and therefore augmenting the meaning of data through social media, also gave rise to IoT-products like Nike+.

The current trend of IoT is also much about home automation control and monitoring, also refereed to as "Smart Home". This involves switches and knobs are being made wireless and configurable and houses can be remotely monitored. Sensors and identification (RfID) is in the core of IoT, but we do not see that much about how data can actuate in a physical context.

The actuators that are most commonly are:

- sound
- light / coloured diodes
- vibration

A common interpretation of IoT is to view it as a network of objects, like the network of computers we already know. When more objects are given connectivity we can gain huge amount of new data that can help individuals as well as society take better decisions. (Robert Fabricant in Connecting, Bassett et al. 2012; Creative Director Scott Nazarian, Frog Seattle. Frog 2013)

IoT, Summarised:

- Every object possesses an ID and location/sensors. There are endless possibilities in data analysis
- Today we see phones as *hubs*. Transition to self-connected microcontrollers and stand-alone objects. (search on Google for your lost glasses)
- Personalisation, "quantified self" and tracking
- Products strongly linked with networked systems and services

2.2 Hybrid Products and service avatars

Kutsen et. al (2011) defines Hybrid products as a mixture of physical product, services, media, social media and interactions (Knutsen et al. 2011). Internet is not *one* thing we "go onto" anymore, but something that is integrating and surrounding us more or less continuously and we need to consider this new phenomenon (the connections) as a *design material* (Knutsen et al.

2011) (Kuniavsky 2010) side by side with steel, injection moulding and costs. In the context of curating a exhibition on hybrids, Knutsen et. al (2011) experience one of the core challenges with hybrid products: how to communicate the intangible and invisible services and networks that work along with the physically present object? (Knutsen et al. 2011)

About the same time as Knutsen et. al published their work, a young Dutch design studio published a book entitled Meta Products (Rubino et al. 2011). They identify meta as the mix of people, environment, services and information and the web and network as the carrier of information. Whereas Knutsen et al. seems to acknowledge the network (almost in a technical sense) Meta Products look upon information as "the fuel" in the system (Rubino et al. 2011). Knutsen et. al are more concerned with the network as an interface and the importance of the carrier. "Fuel" is also being used to describe the new information gained from new sensors. Both of these research clusters have in common their reference to Mike Kuniavsky and his "service avatars" (Knutsen et al. 2011; Kuniavsky 2010). In this context, a service avatar represents the physical component of a hybrid product. Service avatars represent a shift in value, from *the object* to *the service* (Kuniavsky 2010). Kuniavsky (2010) uses the digitalisation of TV-networks as an example showing how little the analogue TV was worth in the moment that the service changed from analogue to digital. In the movie Objectified (Hustwit, 2009), the iPhone is uses as an example of interaction with an avatar, where the physical form almost has disappeared as a result of services. The phone has become a rectangular volume witch fades away in the moment we use it, it is almost as the physical component has been reduced to a carrier. Although Kuniavsky is viewing the service as the value, and the product as the carrier, Kuniavsky underline that as long as the user uses a *smart thing*, "the product *is* the service", meaning that industrial and interaction design must be applied to help communicate the service, giving identity and emotions (Kuniavsky 2010). This is important as physical artefacts can easier be given own meaning and becoming more personal with use.

On April 28 2013 Apple could celebrate 10-year anniversary for the music store iTunes. The introduction of the store converted the iPods to hybrid products or service avatars and boosted the sales of iPods (Rubino et al. 2011) (Kuniavsky 2010). Although the link between the service and the physical product was a bit cumbersome initially, the event marked a milestone in the history of hybrid products.

2.3 Summary

- IoT has focus on sensoring and identifying.
- *Hybrid products* is a designerly response to the more technology-driven IoT.
- Hybrids represent merge of product, interaction and service design disciplines.
- The physical component of and Hybrid product reassembles Kuniavsky's "service avatar"
- There is a shift in value from the object to the service
- The avatar *is* the service in the moment of use, and the physical component can help communicate the service, giving emotions and identity.

3. TANGIBLE EMBODIED INTERACTION

Tangible embodied interaction (TEI) is a wide research area that encompasses fields like human-computer-interaction, computer science, interactive art, and industrial design (Hornecker 2013) (Hornecker 2009). In this article only some of the most relevant aspects of physicality in relation to hybrid products are presented. TEI is being approached from many professions and different views. This article's view is closest to what Eva Hornecker call the "Expressive-Movement-centred view" (Hornecker & Jacob 2006), summarised as a designerly approach to exploring the action and sensory potential in

physical objects. This view is elaborated later in the section “Aesthetics of interaction”. Much of today’s research on TEI has been influenced by the work done at MIT Media lab, manifested by Ishii and Ullmer’s paper on “Bits and Atoms”. Their vision was to give “physical form to digital information”(Ishii & Ullmer 1997), with a seamless interface between the two. The folks at MIT Media lab wanted to enrich our experiences with digital information by bringing in physical interaction(Ishii & Ullmer 1997; Hornecker 2011). In the “social-digital-age” we now live in, the challenge might be more balanced as new behaviour and possibilities have risen with the Internet and its things.

3.1 Physicality in TEI

Hornecker is one of the main contemporary researchers regarding physicality in TEI. She claims that our tactile sense has been undervalued and points out how touch is multimodal, how we cannot touch without being touched (Bilton & Markoff n.d.; Hornecker 2009). Materials give properties exampled by weight – which for instance affects our use and understanding of the interface or object. Physicality also implies a bodily presence in space, which holds meaning in relation with the context (Leader 2012; Hornecker 2011). Hornecker underlines how our perception and orientation in the world is based on our body as the central reference point (Lohr 2011; Hornecker 2009) and how objects exist that in the spatial space can meet our bodily experience rather than solely be based on our cognitive skills (Yared n.d.; Hornecker 2009).

3.2 Legibility

Durel Bishop’s marble machine (Figure 1) (Bassett et al. n.d.; Ishii & Ullmer 1997) is one of the most cited examples of a legible interactive device (Frog 2013; Jones n.d.). Every new message is represented physically by a marble rolling into a bowl. Placing the marble in another small indent on the machine is playing back the messages. The concept is clear and intuitive and after a minimal time with the machine, you would know how to operate and read it. It is based on basic affordances, as the ball “wants” to be picked up and placed in another corresponding spot.

Some of the same focus on legibility can be observed in Bishop’s more recent work together with the design agency Berg.

Figure 1: Marble answering machine and Connbox.

In collaboration with Google Labs they work on the project titled Connbox (Figure 1)(Knutsen et al. 2011; Jones 2013). In a contemporary context where GUI and computing are fundamental elements of everyday activity they explore how videoconferencing could be done with a dedicated physical device (Knutsen et al. 2011; Jones 2013). They try to merge established digital and physical interaction patterns into a system that is as evident as possible. The team at Berg emphasise on understanding their technology, and making clear and evident interfaces that are readable. Instead of purely imitating one world, they aim to combine the two into a co-working system, merging digital and analogue culture. (Kuniavsky 2010; Jones 2013.).

3.3 Affordance – an invitation to action

Products need to be understood, they need to convey their intention, purpose and use in a clear and understandable way. Donald Norman (Knutsen et al. 2011; Norman 2002) brought the expression “affordances” into interaction design practice, inspired by the psychologist James Gibson who introduced the term from a perceptual psychology view. Norman emphasised

how objects should be suggestive in their interaction with humans (Rubino et al. 2011; Norman 2002). Objects should give clues about how they are meant or could be used (Rubino et al. 2011; Norman 2002, page 9). According to Normans elaborated (Norman 2004) definition, affordances are a combination of actual properties (material, shape) and perceived suggestions. (Kuniavsky 2010; Soegaard, 2010).
Norman's definition of affordance has been criticised for not being clear enough about the distinction of the affordance and the "perceptual information that specifies the affordance"(Kuniavsky 2010; Soegaard n.d.). Norman's definition is culture dependent and might be criticized for mixing in semantics and codes in his definition. Anyhow, the *actual properties* Norman refers to imply that every object, designed or not, have certain "inborn" characteristics by nature. As humans living in a bodily world (Rubino et al. 2011; Hornecker 2011) we have stored a library of affordances and understandings of the potential interaction with objects and environments. This library helps us interact and understand the world based on a kind of bodily knowledge gained from a continuous contact with new objects, materials, textures and so on. This means that while designing physical objects we have a bigger and more consistent library of affordances to utilise than in GUI design; both by turning to the well established patterns and codes and by the general experience and understanding we have from physicality in our lives.

Gibson's view on affordances is not taking culture into account and is more focused on the bodily possibilities a human has towards an object or environmental context (Soegaard, 2010). This means that when a small child/baby approaches a chair, the relationship between the two does not afford sitting (Kuniavsky 2010; Turner 2008) . But the same chair would afford sitting for the same human some years later. These theories underline how complex our physical interaction with the world is. At the same time it helps us understand how endless the possibilities are regarding giving tangible life to the Internet.

3.4 Perceived Affordances in GUIs

With the introduction of smart phones and rapid growth of screen based interaction, culture and social behaviour, the digital world has started to live on it is own premises. This means that the perceived affordances not necessary must derive from the physical world (Hornecker 2013; Terrenghi et al. 2007).The scrollbar is an example of perceived affordance in a GUI – by it is size it tells us how fast we need to move it relatively to the contents length. GUI has traditionally been borrowing metaphors from the physical world of interaction patterns and computing witch lately has lead to a discussion around whether this so-called skeuomorphism is a good thing or not. This discussion may be an indication that we have started to develop more native codes and conventions in GUI, and that we don't find mimicking the real world that effective anymore (Hornecker 2009; Terrenghi et al. 2007).

Understanding this new digital culture (including perceived affordance, codes, behaviours, UIs) is crucial when trying to include it in physical products. How will the digital affordance and behaviour materialize within a physical context? The answer does not lie solely in the physical component; physicality is not only something that help us reach into the digital culture, but also something that can help the digital world reach out into the physical context.

While GUI can adopt and develop new digital perceived affordances there is a challenge in the rapid change in digital content. This means that the perceived affordances in the context of GUI are less consistent and more arbitrary then the physical. They change fast and new interaction ideas are so easily developed that people all the time have to learn, and "check" whether an interface is acting as presumed.

3.5 Feedforwarding

Tom Djajadinigrat et al. (2002) has for the last decade been working on a wider or slightly different view on Norman's work. They

emphasise the need for *communicating the purpose of an action* (Hornecker & Jacob 2006; Djajadiningrat et al. 2002) rather that *guiding the user to the right action*. The goal of the user is fundamental, not the action per se. Djajadinigrat introduced feedforwarding as a mean of making clearer what the consequences of a potential action would be. Vermeulen and Luyten (2013) present a clear figure of how this relates to Norman's Action model. When designing hybrids and their interfaces, understanding what means of feedforwarding are applicable, and how the feedforward relates to the objects potentially changing goal, is important.

3.6 Aesthetics of interaction

According to Djajadinigrat et al. (2004), the challenge in feedforwarding lies in the creation of meaning. Users must understand what the possible outcome of an action is. Djajadinigrat claims that this meaning should be designed or "given form" trough the interplay of actions and form, and address a shift from data-centred view to a more perceptual-centred view (Djajadiningrat et al. 2004). The *direct approach* (Figure 2) is presented as an alternative in creating meaningful interaction. This approach utilises the sensory-richness and action-possibilities in physical objects. When the semantic approach represents a more classic approach based on our cognition and the use of signs and metaphors (comparable to other known concepts), the direct approach has action and behaviour as core. In this view, affordance is related to what we can perceive and achieve with our body.

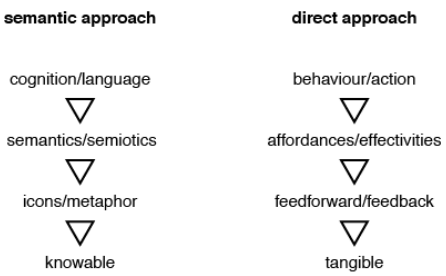

Figure 2: Direct vs. semantic (Djajadinigrat et al. 2004).

As this approach emphasises the possibilities in our bodily capabilities it is natural for Djajadinigrat to look more holistically on our capabilities (Figure 3). Djajadinigrat argues for more focus on our emotional and perceptual-motor skills, as much of HCI has focused on our cognitive skills. He also describes how the two are linked (for instance emotional state vs perceptual-motor skill) and how investigating possibilities within this field can make more endurable interactions and products that are "beautiful in use". (Djajadiningrat et al. 2004)

Figure 3: Djajadinigrat's trinity. According to Djajadinigrat there is big potential in addressing our emotion and perceptual-motor skill when designing tangible interfaces.

3.7 The tangible interface as embodied part of the product.

Tangible interaction has almost been seen upon as an alternative experience to pointers and touch screens – but it can also be used in combination. Much of the research in TUI seems to get lost in technicality, and needs to blend more with the total experience of the physical product.

Successful implementation of TUI is where the UI is not a technical exercise to replace existing UIs; It is where the TUI become a natural, integrated and embodied part of the object. "Plugg" by the Oslo-based design studio Skrekkøgle is an example of this (Figure 4). Plugg also fits into the thinking of Djajadinigrat et al. on both appearance and action as equally worthy carriers of meaning (Djajadinigrat et al. 2004). Plugg is a DAB radio concept that is mainly operated by removing and replacing a tap. When the tap is removed the radio is turned on. By reinserting

the tap the radio is turned of again. Other, secondary functions can be pre-set underneath the radio. This radio is a simple product that combines metaphors and action, affordances and tangibility in a way that is poetic, readable and understandable – and quite independent from cultural background or skill. The interface has become the product and vice versa, and there is a certain "aesthetic of interaction" as Djajadinigrat would call it. Plugg becomes *beautiful in use*. (Djajadiningrat et al. 2004).

Figure 4: "Plugg". Skrekkøgle merges the user interface with the product in a narrative way where traditional user interface elements as knobs and buttons are removed.

3.8 Summary

- Physicality equals sensory richness and great action potential, not accessed with touch based interfaces.
- Physical objects can negotiate and dialog with our bodily experience
- Concepts of affordance, legibility and feedforwarding are strongest in physical execution.
- There is a potential in more emotional and perceptual-motor oriented interfaces.
- God products are "beautiful in use".
- Interfaces as embodied part of product.

4. CALMNESS, DEDICATION & EMOTIONS

This section discusses physicality in the light of our relation to computational technology, like the Internet. This network of computers and sensors potentially delivers massive information. The role of the physical component in our relation to this abstract organism is discussed trough the influential thoughts of Mark Weiser and Mike Kuniavsky. Can physicality help us relate to all this information, and how can emotions and narratives make this data useful and human?

4.1 Prioritisation when moving to the periphery

In the interaction design documentary Connecting (Microsoft, 2012), Younghee Jung (Nokia research) points out how she finds us "a little bit confused about what is important in life". She points out how our connected lives are being affected by all the possibilities that our small, portable screens provide. This is a worry we can recognise from the past, carrying discussions on information overload, value and the effectiveness of multitasking. Designer and professor Paolo Cardini conceptualises the issue with the "Monotask" project (Cardini 2012). Cardini makes a rhetoric point out of downgrading the functionality of his iPhone with a set of front covers.

Figure 5: Restricting iPhone covers by Cardini (2012).

Cardini uses humour and design to make a valid point, but does not provide many answers besides limiting access and functionality.

While these are recent examples, Mark Weiser and John Brown presented ideas on how to "calm

down" technologies like these already in 1996 (Weiser & Brown 1996). Their answer is to let information/technology shift out and in of our attention, letting it live in the *periphery* until needed or relevant. By letting the information slide back and forth into our attention we can save our efforts on what is in the centre (Bakker et al. 2010). It is like having a window where the outside activity gives clues that are easy to access if needed. Someone stares inn – wants your attention. Heavy rain – stay at work a bit longer. Weiser and Brown has a physical-spatial (bodily) fundament and emphasise on how giving technology or computers "locatedness" and physicality, it becomes calm and *at home* (Weiser & Brown 1996). This somehow resembles the thoughts of Morrison and Fukasawa – the character and extended functionality of an object should be latent – making it calm (normal), although rich when given attention (Morrison 2006) (Ito n.d.). This theme also closely relates to the previously mentioned *legibility.* The marble machine is calm because it its readable in the periphery. User interfaces (UI) in the periphery are sometimes called Glanceable UIs, where *glanceability* refers to "enabling quick intake of visual information with low cognitive effort" (Mathews et al. 2007). This thinking builds upon Weiser and Brown.

Making peripherals implies a certain level of prioritisation. How are peripheral clues given form in order to be reached from within the centre of our attention? What are the physical, mechanical or state changing attributes acting, and what is the core character giving information/functionality to be chosen in a hybrid product? The ones that give *just enough* clues and information? Regardless of the answer to these questions, there is a significant amount of prioritization involved when forming the physical properties and character that can manage to speak on behalf of the rich digital life of a hybrid product. Their theory also means there needs to be some kind of *dedicatedness* in order to obtain familiarity and a understanding of "what is happening (…), what is going to happen, and what has just happened" (Weiser & Brown 1996).

4.2 Dedicatedness

Kuniavsky (Kuniavsky 2010) describes a shift from generic devises to more specific and specialized ones as they become hardware avatars (hybrids) (Kuniavsky 2011). This means less compromises and potentially better user experience, hence value. At the same time he addresses an issue with apps changing rapidly and does not give clear answers to how a physical avatar cope with the change in software. (Kuniavsky 2011). Earlier firmware updates of electronic devices were left for enthusiasts. With hybrid products change in software and backend computing can change even without the user noticing. Kuniavsky calls these unresolved challenges, but outlines how focus on core functionalities and adaption are important strategies (Kuniavsky 2010). New hybrid products should have as few unfamiliar elements as possible, especially regarding interaction patterns. Also functionality should be held to a core thus being *"flexible enough that future adaption is possible"* (Kuniavsky 2010). Two products that handle this well is the thermostat "Nest" (Figure 6) and the "social printer" Little printer (Figure 7).

Figure 6: Nest Thermostat, by Nest Labs.

Nest is a hybrid product. It is basically a thermostat that learns how you heat your home. It features a really simple interaction principle, turning the outer ring of the object. This interaction principle is closely bounded to the concept of lowering and rising temperature and uses affordance and pattern of a knob. The background "wealth" can be accessed with a

phone or computer. Nest has made a dedicated product and interaction basis witch has a high degree of adaptability.
"The little printer" is another good example of a dedicated but versatile hybrid product. It is more than a small printer as it has a highly customizable service behind it – it can easily be personalised. Through a web/phone interface the end user can create it is own little newspaper including messages and notifications from friends. As soon as the printer has something to share, a small light start to pulse on the top of the printer, telling from the periphery that it has something to share. The printer has hybridity to it in many ways, and certainly matches Kuniavsky's focus on core functionality. It is dedicated to printing on a roll of thermal paper. Versatility, or adaptiveness lies literally in the white canvas on which the service delivers the content.

Figure 7: Little printer, by Berg London.

4.3 Narratives & emotions.

The people behind the little printer emphasise how designers must use narratives and character when making hybrid products (Hill 2013). They work in the tradition of Weiser, Isshii and Bishop and their attention to calm, playful, and emotional factors are evident. In fact they are literary inspired by cartoons and toys like Pixar and Lego (Hill 2013). BERG is convinced that successful hybrids are a result of technology that feel more human, by giving it real life behaviour through character and narratives, and they believe the physical form is suited for this task (Hamburger 2012). Another hybrid is the personal activity tracker Shine (Figure 8) by Misfit Wearables, co-founded by the former CEO of Apple, John Sculley. While there are plenty of trackers out there, as the mentioned Nike+, Shine has done something that make them stand out. They have made something that resembles a small locket, jewellery or amulet (metaphors). Something small and touchable, that could we used even if it did not work (Fehrenbacher 2013). The tracker can be worn in many different ways, and by tapping it an array of diodes light up – indicating if you have reached your desired amount of activity. Misfit has made a desirable physical object that becomes intimate because of it is size, behaviour and touchability (Fehrenbacher 2013). This touchability is what Hornecker refers to as *deeply emotional* that the responsiveness and dialogic qualities of touch have immediate emotional response (Hornecker 2011). Om Malik, writer and founder of GigaOM claims that understanding of the relationships between empathy, storytelling, emotion and data is the key to future successful technology business. As data and technology becomes cheaper and more available, the winners wont be those how makes the best machines, but those who have "the ability to ask human questions" (Malik 2013).

Figure 8: Shine. Personal Activity tracker by Misfit.

4.4 Summary:

- Physicality can make technology calm and *located* by moving it to the periphery.
- A focus on core functionality is important, but the hybrid must be flexible enough for future adaptation
- A high level of dedication in the physical component result in more familiar and legible products.
- Emotions and narrative makes big data useful. Physicality is suited for telling these stories and communicating with our emotions.

5. DISCUSSION

Designing for tangible interaction is complex and expensive. The physical, in contrary to its digital counterpart cannot be modified or changed easily. It is expensive and time consuming to develop physical products and although a holistic approach to designing hybrid products is required it is important to design the physical with future content/software change in mind. Both the software and the physical product need to be well designed and in particular the intersection of the two. It is in the translation or common language between the digital and the physical the challenges are located. The conflict in designing something dynamic, endless and changing into a static physical object is evident. Understanding the role of the physical component in this relation is crucial. Many interaction studies try to find universal principles for tangible interaction. Such a universal approach does not fit when making hybrids. Hybrids like little printer or Shine are made from the bottom up, telling stories and meeting users as emotional humans, using physical properties. Their process also involves striving for an embodied and natural interaction concept, which can resonate both with the digital, and the physical world. The process seems similar to a classical design process, although many of the materials are swapped with networked data and new digital behaviour. Understanding these components is as important for hybrid products as understanding wood, metal and plastics are for classical product design.

In my own exploratory design project (Figure 9), I made a Wi-Fi enabled "knob" that could either communicates with an equal knob, or be programmed by the user as a physical display of peripheral – hence becoming a hybrid. In dialog with experts from the field of industrial design, arts and computing, several of the interviewees pointed out how the wood was warm, non-technological and would easily gain patina based on the end users interaction, hence become personal by use. While playing with the objects, sometimes a delay occurred in the transfer of signals, resulting in the objects start to move by it self – as if it had become alive. Some people became fascinated and found the things cute and funny, others questioned the technology. Could it be trusted, both in a technical sense, but also personal policy vice. How will our relation to artefacts around us evolve if every object is a potential computer or sensor? What happen with the data? When the object was used as peripheral or physical display, it was interesting to see how many different user scenarios and concepts evolved from one single physical actuation. Some people questioned the longevity of such a product, while others found it fun and interesting, pointing out how Facebook and iPhone depended their daily routines were.

Figure 9: While turning the bottom knob on one of the objects the other's head would start to turn in a 1:1 relation. The objects where connected to Internet by wifi (electric imp), but had an exterior totally made out of wood. To the right, the peripheral state.

5.1 Benefits & Challenges

Physicality can help make the huge amount of data gathered though networks reachable and valuable for people. Addressing our emotional and motor-perceptual skills when designing hybrids, even using simple means like materials and size can make hybrids personal, hence valuable for people. The attention to storytelling and emotions seen in much traditional design practice, often lack in IoT-products, and should be addressed by designers, as physicality is suited to tell these stories, and make more personal products.

There is a relief in constraints. By creating a physical platform as constraint, users can focus on one task or set of information and interpret without effort. Physicality can help making networks and data accessible in a way that is not demanding cognitive wise, by constraints or by designing glanceable UIs**.** At the same time is important that the physical part has a level of flexibility, so that it can adapt to change in data. An example of this is for instance the bracelet UP, by Jawbone (Figure 10).

Figure 10: UP, by Jawbone, is living it is own physical life –communicating by vibrating– but can be given new meaning by connecting it to an app.

But physicality is also about prioritization. The way we live with media has a multitask-high input-flow to it. By making products that focus and stay in our periphery until we need them, we can make technology calm.

The same prioritization is doing for data (big data, quantified self) what smart phones did for web regarding user experience – taking away useless components and focusing on the most important content. It is about sorting out what is really important for the users. When designing physical products you are forced to do this.

More and more actuated products, also as hybrids enter the marked. We see a broad use in the use of light to express digital communication and behaviour. The most commonly used are also the most generic ones; sound, light, vibrations. This is often suitable - but there's a potential for investigating more tangible experiences. This investigation is going on in the 'do it yourself' movement, and through crowd founding services like Kickstarter.com. This means new dedicated physical products (also hybrids) get out and rapidly tested by early adopters, contributing to the learning around dedicatedness and how these products should behave and be experienced.

5.2 Further on

To what extend should hybrids be dedicated, and how many of this kind of interactive devices can we keep around? Our lives become more and more digital, accompanied by new advantages and challenges. Understanding digital culture and how it relates to the physical world is a domain that's becoming increasingly important for designers. As products become hybrids, maybe also designers need to be more hybrid, working even more closely with other disciplines.

From a functionalist perspective a question arises regarding how form follows function in a hybrid. The function of a hybrid is not solely bound to the object alone, but also the networked objects or services. How do we deal with this? These questions relate to several of the discussed topics in this paper, but need further elaboration. The relationship between humans and technology has always been in the centre of designers practice. We see the contours of a new paradigm regarding the possibilities in digital and networked data, hence how this new technology relates to traditional product design. Entering this era, designers need to iterate on our thinking about how to make technology useful for people.

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