

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. The methods used are a literature review with product design as a point of departure and an experiment with investigative prototyping. 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 sufficient amount of flexibility incorporated. It is also argued that physicality is good at narratives and emotions, two important elements in making data useful and graspable for humans. For new products, successful implementation of physicality is achieved, 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 decade there has been a rapid growth of domestic products having 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 development of digital infrastructure and mobile devices has made it possible to connect objects in the same way as computers. Although these new products are increasingly referred to as The Internet of Things (IoT) in public media, they include wide set of technologies and perspectives with quite blurry distinctions.

In this article we use the term Hybrid products (hybrids), as introduced by Jørn Knutsen et al. [1]. Hybrids are products that are made with a „designerly“ approach, not solely focusing on the technology/opportunity-driven possibilities often seen with IoT-products. They focus on the interplay of digital and physical materials and the connection between a physical device and digital networks [1]. The scope is to discuss the merging of product, interaction and service design and the relationship between humans, products and the Internet.

With these limitations we discuss the particularities of the *physical component* of a hybrid product. The word *Physicality* emphasises the ecological quality of these components rather than a focus on their mechanic properties. In the narrowest definition, physicality could be

tangible objects or bodies, and the spatial relation between these objects and us [2]. 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 etc. Physicality has also been connected with our cognition [3]. In this article physicality represents the located body in relation to the tangibility and materiality of the hybrid product.

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 "Tangible Bits"[5] Ishii and Ulmer initiated among others, a quest for re-joining the richness of the physical world with computers. They discuss 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. 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" [6].

1.1 Method

Literature from a wide set of research areas and sources has been reviewed for this article, with product design as a point of departure. Much of the recent work on hybrids is yet to be represented in scientific articles, and several of the sources are from articles and magazines on the Web. The focus of the search has been to find the main inspirations for designers and researchers working with hybrid products. 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. Particularly insights on the role and the strengths and weaknesses of the physical component in hybrid products are considered.

Complementary to the writing, the first author carried out an investigative design project, exploring some of the key themes in this article. The project concluded in seven interviews where reactions to the resulting prototypes and possible implications were discussed. This work is only briefly presented in this article.

2 Hybrid Products & Internet of Things (IoT)

Many terms denote the new products, systems and services Hybrids: connected objects, smart objects, Internet of everything. IoT is however the most common term.

2.1 Internet of Things

At The International Consumer Electronics Show (CES) in 2013 IoT reached the attention of the mass media. Especially in consumer products everything was to be connected and gathering data. Although we have been living in a 'connected' world, with lots of embedded sensors and actuators (visa-, metro-cards, NFC/WIFI, toys) there is a growing interest in bringing the Internet out in the physical world and vice versa [8]. 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" [9]. The possibility of sharing through digital services, and therefore augmenting the meaning of data through social media, also gave rise to IoT-products.

IoT is also about home automation and monitoring, often referred to as "Smart Home". This involves switches and knobs becoming wireless and configurable and houses that 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 initiate physical actions. 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

2.2 Hybrid Products and Service Avatars

Knutsen et. al define Hybrid products as a mixture of physical product, services, media, social media and interactions [1]. 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* [10] side by side with steel or injection moulding. In the context of curating an exhibition on hybrids, Knutsen et. al experienced one of the core challenges of hybrid products: it is difficult to communicate the intangible and invisible services and networks that work along with the physically present object [1].

A different line of thought is presented by a Dutch design studio in “Meta Products” [11]. 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. seem to acknowledge the network, in a technical sense Meta Products look upon information as “the fuel” in the system [11]. Knutsen et. al. are more concerned with the network as an interface and the importance of the carrier. While “Fuel” is being used to describe information gained from sensors. Both of these research clusters have in common their reference to Mike Kuniavsky and his “service avatars” [10]. A service avatar represents the physical component of a hybrid product, the focus moving from *the object* to *the service* [10]. Kuniavsky 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 [12], the iPhone is used 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 which fades away in the moment we use it, 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, he underlines 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 [10]. This is important as physical artefacts can more easily be given their own meaning and become 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 [10],[11]. 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.

3 Tangible Embodied Interaction

Tangible embodied interaction (TEI) is a wide research area that relates to fields like human-computer-interaction, computer science, interactive art, and industrial design [13]. The view in this article is closest to what Eva Hornecker calls the “Expressive- Movement-centred view” [14], summarised as a designerly approach to exploring the action and sensory potential in physical objects. This view is elaborated later in section 3.6.

In the “social-digital-age” we now live in, the challenge might be more balanced as new behaviours and possibilities have risen with the Internet and its things.

3.1 Physicality in Tangible Embodied Interaction

Hornecker is one of the leading authors 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 [2]. Materials give properties exemplified 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 [15]. Hornecker underlines how our perception and orientation in the world is based on our body as the central reference point and how objects exist that in the spatial space can meet our bodily experience rather than solely be based on our cognitive skills [2].

3.2 Legibility

Durel Bishop's marble machine, shown in Figure 1 is one of the most cited examples of a legible interactive device [5]. 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.



Figure 1: Marble answering machine and Connbox.

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. Similar focus on legibility can be observed in Bishop's more recent work together with the design agency Berg. In collaboration with Google Labs they work on the project titled Connbox also shown in Figure 1. [16]. 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 [16]. They try to merge established digital and physical interaction patterns into a system that is as evident as possible. The team at Berg emphasises 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 cultures [10],[16].

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 brought the expression “affordances” into interaction design practice [17], inspired by the psychologist James Gibson. Norman emphasized how objects should [11] and clues about how they are meant to be used [17]. According to Norman's elaborated definition [18], affordances are a combination of actual properties (material, shape) and perceived suggestions.

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" [10]. Norman's definition is culture dependent and might be criticized for not taking semantics and semiotic codes into account. 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 [11],[15], we store 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 larger and more consistent library of affordances to utilise than in GUI design; both by turning to 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. This means that when a toddler approaches a chair, the relationship between the two does not afford sitting [10],[20], as it would for an adult. These contrasting theories show how complex our physical interaction with the world is. At the same time they may help 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. Perceived affordances do not necessarily have to derive from the physical world [13]. GUI-development has traditionally been borrowing metaphors from the physical world, which lately has led to a discussion around whether this skeuomorphism is a good thing. 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 [2].

Understanding this new digital culture (including perceived affordance, codes, behaviours, UIs) is crucial when trying to include it in physical products. How will digital affordances and behaviour materialize within a physical context? The answer does not lie solely in the physical component; physicality is not only something that helps us reach into the digital culture, but also something that can help the digital world reach out into the physical context. However, there is a challenge in the rapid change in digital content. Perceived affordances in the context of GUI's are less consistent and more arbitrary then physical affordances. They change often 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

Djajadinigrat et al. have for the last decade been working on a broader or slightly different view of Norman's work[22]. They emphasise the need for *communicating the purpose of an action* rather than *guiding the user to the right action* [22]. The goal of the user is fundamental, not the action per se. Djajadinigrat introduced feedforwarding as a means of making clearer what the consequences of a potential action would be. This may be related to o Norman's Action model [23]. When designing hybrids interfaces, understanding what means of feedforwarding are applicable, and how feedforward relates to the objects potentially changing goal, is important.

3.6 Aesthetics of interaction

According to Djajadinigrat et al. [24] the challenge in feedforwarding lies in the creation of meaning. Users must understand what the possible outcome of an action is. This meaning should be designed or “given form” through the interplay of actions and form, and address a shift from a data-centred view to a more perceptual-centred view [24]. The *direct approach* (Figure 2) is presented as a way of creating meaningful interaction. This approach utilises the sensory-richness and action-possibilities in physical objects. While the semantic approach represents a more classic approach based on our cognition and the use of signs and metaphors, 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 approach.

&

Djajadinigrat's trinity. [24].

As this approach emphasises the possibilities in our bodily capabilities it is natural for Djajadinigrat to look more holistically on our capabilities (Figure 2). The triangle figure argues for more focus on our emotional and perceptual-motor skills, as much of HCI has focused on our cognitive skills. The two capabilities are linked (for instance emotional state vs perceptual-motor skill) and investigating possibilities within this field can make more endurable interactions and products that are “beautiful in use” [24].

4 Calmness, Dedication & Emotions

This section discusses physicality in the light of our relation to computational technology, like the Internet. 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” [25], Younghee Jung from Nokia 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 [26] where he makes a rhetoric point out of downgrading the functionality of his iPhone with a set of front covers. 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, Weiser and Brown presented ideas on how to “calm down” technologies like these already in 1996 [27]. 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 [28]. It is like having a window where the outside activity gives clues that are easy to access if needed. Someone stares in – wants your attention. Heavy rain – stay at work

a bit longer. Weiser and Brown have a physical-spatial (bodily) fundament and emphasise on giving technology or computers “locatedness” and physicality, it becomes calm and *at home* [27]. 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 [29]. This theme also closely relates to the previously mentioned *legibility*. The marble machine is calm because it is 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” [30].

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? How 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? 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.

4.2 Dedicatedness

Kuniavsky describes a shift from generic devices to more specific and specialized ones as they become hardware avatars [10]. 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 copes with the change in software [31]. 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 [10]. 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*” [10]. A product that handles this well is the “social printer” Little printer.

“The little printer” is 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 a 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.

4.3 Narratives and emotions.

The people behind the little printer emphasise how designers must use narratives and character when making hybrid products. They work in the tradition of Weiser, Ishii 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. They believe that successful hybrids are a result of technology that feels more human, by giving it real life behaviour through character and narratives, and the physical form is suited for this task [33].

5 A Design Project

To explore some of the concepts we made a Wi-Fi enabled “knob” that could either communicate with an equal knob, or be programmed by the user as a physical display of

information (Figure 3). The prototype was tested by experts from the field of industrial design, arts and computing. In a follow up interview 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 itself – 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 on the personally. How will our relation to artefacts around us evolve if every object is a potential computer or sensor? What happens 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 3: The objects are connected to Internet by wifi, but have an exterior totally made out of wood. To the right as connected devices, where turning the bottom knob on one of the objects the other's head start to turn in a 1:1 relation. To the left as an information display.

6 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” 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.

6.1 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 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 make networks and data accessible in a way that is not cognitive demanding. At the same time is important that the physical part has a level of flexibility, so that it can adapt to change in data. 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 market. They are used 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 pursued by the "do it yourself" movement, and through crowd founding services. This means new, dedicated physical products and hybrids get out and are rapidly tested by early adopters, contributing to the learning around dedicatedness and how these products should behave and be experienced.

6.2 Further on

To what extent 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 designers also 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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