

THE CONVERGED APPLIANCE: “*I LOVE IT... BUT I HATE IT*”

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ABSTRACT

The last decade has seen convergence marketed as one response to the challenge of users having to juggle an increasingly wide array of digital services, technologies and media. Key to this view is the assumption that by converging computer devices, and digital media, the value of technology for end users can be maximised whilst the overheads involved in purchasing, maintaining and orchestrating a variety of different technology solutions can be minimised. In contrast however, some authors have argued that convergence creates weak-general solutions, and rather we should be aiming for strong-specific technology by means of the deliberate design of multiple diverged devices. This paper contributes to the ongoing discussion of convergence and divergence. We discuss three apparently irreconcilable perspectives on the relationship between functionality and usability, and show that they are in fact complementary views of convergence. To ground this discussion we draw on the results of a recent cultural probes study of a cohort of early adopters of converged devices.

KEYWORDS: *convergence, divergence, usability knee, user study, cultural probes.*

1. INTRODUCTION

Within the last decade of ICT development, convergence has often been suggested as the ultimate answer to the challenge of users having to juggle an increasing number of different digital technologies and media. The driving force behind this line of thought is that by converging computer devices, and digital media, the value of technology for end users can be maximised while the overhead required for maintaining and combining the different technologies is minimised. Many examples of this approach to technology design exist. Today's digital video cameras often offer high-quality still-photography (see e.g. Sony 2005) and digital still cameras ape some of the functionality more typical of video recorders (see e.g. Canon 2005). USB memory sticks come with the capability of playing their music files directly through headphones (see e.g. Packard Bell 2005) and MP3-players moonlight as large external high-speed hard disk drives (see e.g. Apple 2005a). Other music players show an ability to store digital photos and can be plugged directly into a TV (Apple 2005b). Personal digital assistants (PDAs) are increasingly being combined with mobile phones and multimedia technologies, extending their traditional calendar and contact functionality to include capabilities for voice communication, Internet browsing, digital still photography and video recording as well as personal audio/video playback (see e.g. HP 2005, PalmOne

2005, Archos 2005). Approaching the same functionality, but from a very different origin, the same trend is now clear within the mobile phone market (see e.g. Nokia 2005).

While many of the examples above are ‘strong-specific’ (Buxton, 2001) solutions that have inherited one or more relatively weak implementations of other technologies (such as the personal video players shipping with light-weight PDA functionality or mobile phones with poor quality FM radios), this boundary between primary and secondary functionality is now beginning to blur. As an example of this, digital cameras built into mobile phones are now achieving picture quality approaching their stand-alone counterparts, making one ask if the converged device is a phone with a camera or a camera with a phone (figure 1). In relation to the challenge of interaction design, should such technology mutations inherit the interaction paradigm of the telephone or the camera (Sacher and Loudon, 2002)? Or are either of these paradigms really appropriate?



Dual fronts
Get acquainted with the Sony Ericsson K700. This camera phone heralds the dawning of a new era in mobile imaging. Equipped with a large high-quality colour screen and a VGA camera that also does video, the K700 is a device with dual fronts. As much a camera as it is a phone. Or, to rephrase: as much a phone as it is a camera.

Figure 1: Camera phone or phone-camera?

In contrast to the approach to technology design depicted above, others have argued that convergence creates ‘weak-general’ solutions, with usability comparable to the Swiss army knife: clumsy technology with a wide range of functions, none of which are ideal in isolation (see e.g. Norman 1998, Bergman 2000, Buxton 2001). Responding to the ‘one size fits all’ view, they suggest a single-function/many-device or ‘information appliance’ approach where each device is “designed to perform a specific activity, such as music, photography, or writing” (Bergman 2000). The driving force behind this line of thought is that having a wide range of good specialized tools to choose from is better than having a general one that does not perform any individual task particularly well. Specialized tools facilitate optimisation of functionality over time and the refinement of well-known paradigms of use. In contrast, weak-general tools share much in common with the proverbial camel (‘a horse designed by a committee’); they are hostage to compromise, limited by the accumulated complexity of too many ways of possible use.

As pointed out by Pemberton (2001), although convergence has been a popular topic of discussion within the field of HCI for more than a decade, very little empirical data has been reported on the use of converged solutions. This paper contributes to this ongoing discussion, grounding the contribution in empirical data drawn from studies of technology use. We present and discuss three contrasting perspectives on convergence, and report early reflections on data from a cultural probes study of technology use.

Section 2 of the paper presents and discusses three perspectives on convergences, all drawn from previous work. Section 3 outlines four concepts useful in understanding convergence and divergence in both the design and use of technology. Section 4 briefly presents an empirical study of technology use. Section 5 presents some of the key findings drawn from the analysis of the empirical data. Finally, section 6 discusses the findings in the light of the three perspectives on convergence discussed earlier; we argue that the three apparently irreconcilable perspectives are in point of fact quite complementary.

2. THREE PERSPECTIVES ON CONVERGENCE

The HCI literature on technology design and usability includes, on first reading, three quite different views of the relationship between functional scope and user experience. Let us call them:

- Utopian perspective: User experience is proportionally related to functional scope, “more means more”.
- Dystopian perspective: User experience is inversely proportional to functional scope, “less is more”
- Hybrid perspective: User experience is positively related to functional scope but only up to a threshold value, the ‘tipping point’, after which the Dystopian view prevails.

2.1. Utopian

Darwing parallels with Moore’s Law (i.e. the number of transistors fitting on a single chip doubles every 18 months) a Utopian view of the relationship between functionality and usability seems to be that the more functionality that can be accommodated by one single technology, the higher its usability will be. This view reflects the basic assumptions underlying the push to convergence discussed above. If one device can function as music player, wireless headset and data storage device, associated user experience will be higher than with a ‘toolbox’ of individual devices performing only one of these functions each (see figure 2, Blueant Bluetooth stereo headphones and audio player).

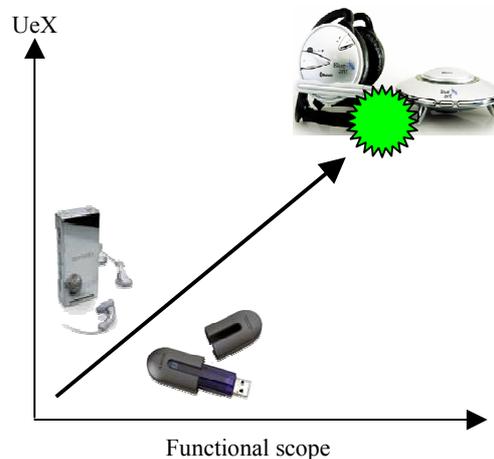


Figure 2: Utopian view of the relationship between functionality and usability

From a Utopian perspective, increasing convergence is the path to enhanced user experience. However, defining the factors relevant to determining a good functional grouping is a non-trivial problem. Further, the Utopian view, held by many technology vendors, does not explain the to date limited success of several converged technologies such as the PDA-phone or the memory stick-MP3 player, and the failure of earlier converged solutions such as video telephony.

2.2. Dystopian

Motivated by the observations that the functional complexity of many ICT’s has already, in a real sense, exceeded the threshold of human problem solving capacity, and that this capacity limitation is stable (referred to as “God’s Law”) Buxton (2001) stands in stark contrast to the Utopians in proposing an inverse relationship between usability and functionality. As the number of functions supported by a device climbs, its usability approximates zero. Unless convergence design is conducted with genuine sensitivity to users, their characteristics and their practices, convergence merely adds complexity to the technology, encouraging workarounds, increasing frustration and introducing inefficiencies. Exemplifying Dystopian view, dedicated mobile phones and torches each have higher usability than a mobile phone with built-in flashlight (as illustrated in figure 3).

The Dystopians sit in the ‘information appliance’ camp introduced above. Introducing a “threshold level of frustration” (Buxton 2001) where the level of functionality intersects with the threshold level of human capacity, Buxton’s view may help explain why some highly advanced novel technologies such as virtual

reality, interactive television, MMS (Multimedia Messaging Service) and video telephony have never really achieved a commercial foothold whilst other strong-specific solutions, such as mobile telephony and SMS (Short Message Service), have had huge success.

While it is relatively simple to implement Buxton's philosophy (simply limit functional scope), this approach does not help in understanding why some technologies have indeed been successfully converged, offering both a high level of functional capability and a positive user experience, such as the camera-phone.

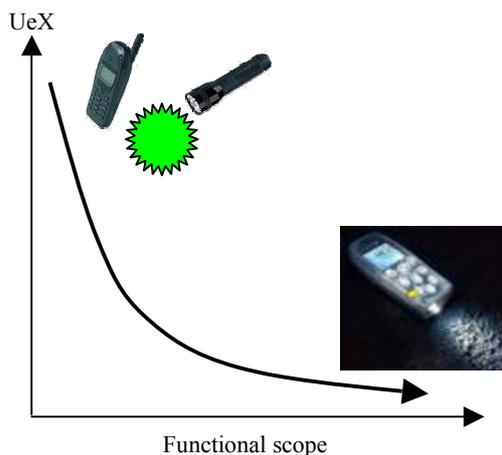


Figure 3: Dystopian view of the relationship between functionality and usability (after Buxton 2001)

2.3. Hybrid

In contrast to both the Utopian and Dystopian views, researchers at Nokia have argued that user experience is not simply proportional (inversely or otherwise) to functional scope (Kiljander and Järnström 2003). Rather they argue that the usability of a specific technology can remain relatively stable (high, low or otherwise) whilst functionality is increased up to a certain threshold value, beyond which usability will drop rapidly (as illustrated in figure 4). They term this tipping point in the relationship between functionality and usability the 'usability knee'. The line of thought behind the usability knee is that each technology platform (such as a specific series of mobile phones) has a certain threshold or critical mass of functionality or functional complexity determined by, for example, its input and output capabilities. Thus, the position of the usability knee on the horizontal (functional scope) axis can be moved further to the right by improving the capabilities of the platform, for example, increasing screen size, screen resolution or creating better input capabilities.

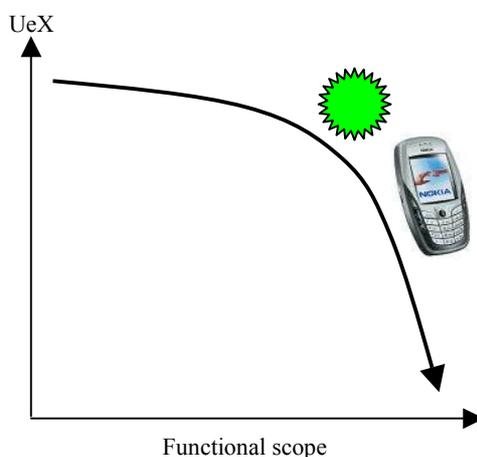


Figure 4: Hybrid view of the relationship between functionality and usability (after Nokia)

Using Buxton's (2001) terminology, the art of technology design according to Nokia lies in striking the right balance between weak-general (i.e. converged) and strong-specific (i.e. diverged) solutions, the right balance between functionality and usability. The trick is to maximise functional power without going beyond the knee of usability.

3. CONVERGENCE AND DIVERGENCE BY DESIGN AND IN USE

All three perspectives outlined above are rather technology-centred. Clearly though, user experience is not only influenced by decisions made during design and development, but also through the act of technology use itself, and the contexts within which that use occurs. Howard et al. (2004) proposed that the interplay between technology, designers and users could be conceptualised in terms of:

- Convergence-by-design
- Divergence-by-design
- Convergence-in-use
- Divergence-in-use

These are illustrated in figure 5 below. Whereas convergence-by-design and divergence-by-design describe the two opposing approaches to technology design, and are unpacked above in terms of the three perspectives, *convergence-in-use* and *divergence-in-use* describe opposing approaches to convergence and divergence as practiced by *users*. Convergence-in-use and divergence-in-use describe how users, not designers, converge and diverge technologies by, for example, integrating them, combining them, taking them apart or using them consciously to supplement each other.



Figure 5: Convergence- and divergence-by-design (top) and convergence- and divergence-in-use (bottom)

Where convergence-by-design creates solutions which can be seen as general (and thus sometimes criticised for being weak), and divergence-by-design creates solutions which can be described as strong (and thus sometimes criticised for being too specific), the concepts of convergence- and divergence-*in-use* capture the mechanisms by which users compensate for the frustrations of a designed technology by creating solutions themselves, which fit their specific needs and contexts of use.

Convergence-in-use describes the phenomenon of users putting together and manually configuring different technologies for certain purposes beyond their originally intended use, exploiting the joint potentials of a range of technologies or overcoming the limitations of some one technology by means of another. Convergence-in-use does not apply only to technologies that have been diverged-by-design (i.e. putting them back together), but also to the further 'use-side' convergence of technologies that has already

been converged ‘design-side’. A basic convergence-in-use solution to controlling a home-entertainment system consists of multiple remote control units physically combined (see figure 5). Stretching this example a little, the increasingly popular home-entertainment system is no longer limited to traditional audio and video components but now includes personal computers functioning as media servers, wireless local networks for remote control and streaming of media files between distributed devices.

Divergence-in-use conversely describes the phenomenon of users deliberately deploying multiple separate technologies to support a single activity, exploiting their individual strengths and compensating for any weakness by supplementing with other technologies. Similar to convergence-in-use, divergence-in-use does not only apply to the divergence of previously converged-by-design solutions (i.e. ripping them apart again), but also to the situation where a range of different technologies, converged- or diverged-by-design, are being used comfortably side-by-side. An example of divergence-in-use is the parallel use of electronic and paper-based calendars (see figure 5).

4. EMPIRICAL STUDY

We seek a better understanding of convergence and divergence as they are experienced in use, and therefore we aim to ground that understanding in the experience of end users of converged solutions. Here we focus on the use of converged devices by young urban professionals. We employed ‘cultural probes’ (Gaver et al. 1999, Vetere et al, 2005) in order to empower our early adopters in the telling of ‘their stories’ of convergence.

Studying people’s use of technology is common within HCI. However, such user studies are often limited to relatively brief snapshots of use in limited or artificial settings. Whilst this approach can generate valuable knowledge about interface design, usability and the usefulness of technology solutions for specific activities or work tasks, it provides only limited insight into *real* technology use over extended periods of time. Studying technology use in-situ is a particular challenge as technology pervades our everyday life. Technology’s influence extends beyond specific physical, temporal and social situations; its very ubiquity renders it ‘unremarked’ upon. Hence, traditional empirical methods within HCI, and more broadly within the social sciences, fall short in capturing a comprehensive picture. ‘Cultural probes’ are designed to give researchers access to these secluded and unfamiliar territories, in part by shifting the task of data collection onto the participants themselves. Supporting this, researchers equip their participants with a series of tools and materials to assist focus, data collection and data reporting, such as digital cameras, voice recorders, notebooks, diaries, scrapbooks, pens, scissors, glue and technology prototypes, all designed specifically for the purposes of the particular study or phenomenon of interest. Whilst being a relatively new approach to ethnographic user studies within the field of HCI, the use of cultural probes has grown in popularity within the last couple of years, and the method has been refined through several studies (see e.g. Gaver et al. 1999, Cheverst et al. 2003, Vetere et al. 2005).

The probe pack used in this study consisted of a diary, a scrapbook, a Polaroid camera and a set of catchphrases prompting the participants to reflect on their use of technology. The participants were asked to use the probe for a period of four weeks. Supplementing the probes, two interviews were carried out with each participant. The first interview occurred one week into the probing period and inquired into a series of general technology questions, and established the degree to which the participants were comfortable with the use of the probes. The second interview was carried out a few weeks after the probes had been returned to the researchers, and aimed to delve deeper into recorded incidents.

All participants were recruited through a professional recruitment company and each was paid approximately Aus\$300 for their involvement. The study originally consisted of six participants, although half way through the study one participant decided not to continue with the probe pack and interviews. Thus, in total, the collected data amounted to 5 illustrated scrapbooks, 20 weeks of written diaries and 10 hours of interview recordings (each interview lasted roughly 1 hour).

The collected data were analysed in two rounds. Firstly, the probe data were provisionally reviewed after participants returned their diaries and scrapbooks, generating individual interview guides for the final round of interviews. Later, probe data and audio recordings from the 10 final interviews were analysed in order to identify themes related to convergence and divergence-in-use.

5. FINDINGS

The primary finding from this study is empirical evidence confirming Utopian, Dystopian and Hybrid experiences of convergence. We may have hoped, naively, to find support for one perspective only, and challenges for the remaining two. Instead, people are evidently using technology converged-by-design, actively engaging in convergence-in-use, frequently experiencing the frustrations of the usability knee, and responding to the usability knee by selecting a suite of alternative strong-specific solutions, thereby demonstrating divergence-in-use.

On the one hand, participants often reported the added value of converged devices with increased functionality compared to what they used to have. Examples of this include the highly popular Blackberry devices, mobile phones with cameras and email capabilities etc. Adopting the Utopian perspective that usability will increase with more functionality, this line of thought was often extended further through expressions of desire for one device that would be good at everything (primarily in the diaries and interviews notes) and through evidence of being engaged in the search for such a ‘perfect device’ (primarily through the scrapbooks, as illustrated in figure 6).



Figure 6: Extract from scrapbook: “in search of the perfect device”

On the other hand, participants also often reported frustrations related to the use of converged devices not providing a positive user experience, designs pushed beyond their usability knee (clear in diaries, scrapbooks and interviews). For example, several participants were using Blackberry devices for diary, contacts and mobile email access with high levels of satisfaction, though all complained about the usability of the built-in mobile phone when compared to a dedicated mobile phone. The points of criticism of the Blackberry’s phone related to both technical issues such as poor user interface, limited contact list functionality, and sound quality, as well as form factor issues such as the device being too big for ‘out of office’ usage (slipping in small handbags or the back pocket of a pair of jeans).

In response to a breach of the usability knee, participants responded in line with Buxton’s view, demonstrating either divergence-in-use by deploying multiple often redundant devices, or divergence-by-design by adapting highly specialized devices. For example, none of the participants actually used the Blackberry device’s mobile phone. Instead, they all chose to carry an additional device, a strong-specific mobile phone.

In summary, the participants optimised their user experience by selecting functionally powerful devices, whilst also carefully spreading activity across multiple devices, in deliberate and intentional ways.

5.1. Increasing usability by means of convergence

The data contain multiple examples of convergence improving user experience by-design and in-use. As an example, most participants make extensive use of mobile access to email and diaries on their mobile devices such as mobile phones, iPAQs or Blackberry. Mobile devices with integrated cameras were also seen as highly useful for people working in the field who had a need for visual documentation – especially when integrated with functionality for sending images directly via email. One of the main motivations reported for adopting converged devices was integration and portability by means of keeping down the number of devices having to be carried around. Increased functionality by means of convergence was not only identified on the form factor level but also on the data level, such as receiving incoming faxes as image files attached to emails. Examples of convergence-in-use included use of the same technologies for work purposes, private purposes and leisure (such as PC’s used for work email, personal net banking and online music downloads).

5.2. *Beyond the tipping point*

The location of the usability knee, the point at which user experience is harmed by increasing functional complexity, depends not only on the technical capabilities of the platform, but also on the users' context: work/private, office/field etc. Movement between the worlds of work and play can change the position of the usability knee (due in part to changing requirements), e.g. some participants were happy to carry a highly converged PDA with foldout keyboard, camera extension, etc. during work hours, but switched to a strong-specific mobile during the weekend.



Figure 6: Extract from scrapbook: "I wish these technologies worked better together..."

Managing the dynamic position of the usability knee across the work/play boundary involves exploiting convergence during design (by providing a PDA with fold-out keyboard etc.) whilst still facilitating divergence-in-use (by keeping the phone separate, or at least detachable)

5.3. *Increasing usability by means of divergence*

Evidence of divergence-by-design improving the end user experience was found in relation to both work and leisure. Some participants were frequent users of dedicated personal music players, such as iPods, even though their PDA or mobile phone was quite capable of functioning as a music player as well. However, because listening to music was typically done outside the work domain, while jogging, going to the gym or during other activities for leisure, the participants were clear that in those situations they did not always require the functionality of their PDA or mobile phone. On the contrary, some of them suggested that this device choice helped them draw a line between work- and leisure-time. Exemplifying divergence-in-use, some participants reported the use of multiple mobile and landline phones in order to separate work and private life. More outspokenly, divergence-in-use was also observed as a reaction to reaching a specific technology's threshold of usability. Examples of this include integration of Blackberry devices with laptop computers for better viewing of attached documents and with mobile phones for better voice communication capabilities. Another example reported in the data concerned the combination of camera phones with high-quality stand-alone digital cameras according to the situation of use (e.g. low quality for leisure and high quality for work). Another observed trigger for divergence-in-use was the separation of work and private activity, due to e.g. fear of Trojan infestation from private use (music download) to business use (net banking).

6. DISCUSSION AND CONCLUSIONS

Design and use overlap, coexist and interplay in compelling ways; the design-side practice that results in interactive products, is continued as a use-side dialogue between the user and the technology. The social and technical influences active as convergence and divergence-by-design transmute into divergence and convergence-in-use are the key to matching converged solutions with converged practice.

A number of such social and technical influences are evident in the current data. For illustrative purposes we will highlight one key influence, that of the interplay between work and leisure. The circumstantial differences between work and play often preferred diverged solutions. The penchant for converged solutions capable of supporting the complex nomadic work habits of many of our early adopters, inverted during periods of leisure. 'Week-end technology' was characterised by stand-alone music players and strong specific, physically small mobile phones. Further our participants maintained the distinction between work and play by using different sim-cards for weekdays and weekends, and separating work

related data from personal data by using multiple address books and calendars. The shift between general-work and specific-play technologies was of psychological significance to our participants. Just as playtime preferred strong specific solutions, so the use of strong specific devices marked that playtime, thus users denoted through device choice the difference between the activities.

The work/play influence is one example of many, and no one perspective on convergence captures the complexity we see in our data. Figure 7 shows that the three apparently irreconcilable views on convergence introduced earlier in the paper may be quite complementary, and reflect subtle shifts in the needs and circumstances of use. The conceptual graph again plots functional scope against user experience (UeX).

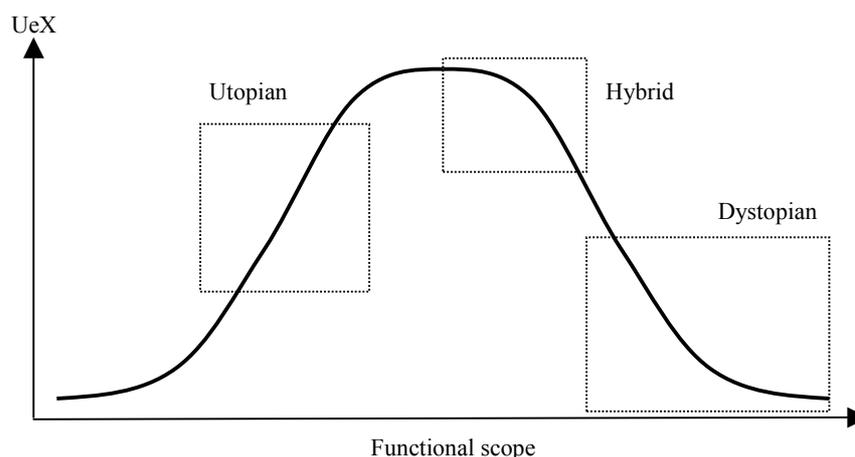


Figure 7: The Convergence Curve - Three complementary perspectives

Each perspective on convergence is a useful spur to design innovation. The Utopian perspective challenges us to seek out convergence opportunities, to explore synergistic collections of capabilities that marry seamlessly to users and the circumstances of use. In relation to work, and their particularly nomadic and multifarious work practices, all of our participants were Utopians. Counter to Norman and Buxton's information appliance proselytising, our participants were eager to adopt cutting edge solutions that supported their converged work practices, keen to seek out an idealised 'strong but general' solution.

In other situations a distinctly Dystopian view emerges. At times of play and leisure, participants preferred niche appliances, and the advantages of strong specific solutions, perhaps tightly integrated through synchronisation support, over their converged counterparts were clearly evident.

Our cautionary tale in this paper, captured in the Hybrid view of Figure 7, is that if designers push convergence too far and in ignorance of user practice, users will push back. From a device vendor's perspective, at best that pushback involves user frustration and divergence-in-use, at worst it results in the user rejecting the technology.

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