Futures xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Futures

journal homepage: www.elsevier.com/locate/futures

# Envisioning inclusive futures: Technology-based assistive sensory and action substitution

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ARTICLE INFO

*Article history:*
Received 4 February 2016
Received in revised form 8 June 2016
Accepted 21 June 2016
Available online xxx

*Keywords:*
Technology
Disabilities
Sensory substitution
Inclusion
Accessibility

ABSTRACT

Mobile devices, tablets, smart phones, and now wearable technologies have changed our world, including how we perceive and interact with others and our environment. This change has potential for both positive and negative outcomes, especially for people with sensory, cognitive, and physical impairments. This work looks at some possible eventualities, with a focus on how these technologies may change the future for people with disabilities.



## 1. Introduction

One thing we can count on is that technology is in constant change; in the past the iterations appeared less rapidly than today's regular stream of new technological innovations in products and services available to consumers. For example, it took 75 years for television, from inception, to reach 50 million viewers. In contrast, a single app, Angry Birds, reached 50 million users in 35 days (Aeppel, 2015). Though the comparison involves two vastly different technology landscapes, it nonetheless signals that adoption rates of software-based applications can be extremely rapid. Moore's Law describes ongoing improvements in computational power and capacity, and consumer products embedding computing technology have made the benefits tangible to the population at large. These changes have also influenced how we interact with technology, with a shift to mobile devices that are more adaptable and personalized, that can be used anywhere and at any time, and away from fixed location technologies such as traditional television and desktop computers (Bouwman & Van Der Duin, 2007). The United Nation's International Telecommunications Union (ITU, 2015) reports that as of 2015, there are 7.1 billion mobile phone subscriptions in the world, which effectively reaches a parity of one phone per person on the planet, and more than three times the number reported in 2005. Smartphones are now in the hands of approximately 2 billion individuals, and that number is expected to continue to grow, as users shift away from the current, globally dominant feature phone. Thriving app stores for the major smartphone platforms offer consumers broad options for social media, education gaming, entertainment, news, and productivity. While there has been past disagreement, many now suggest the smartphone may be the only computer an individual will ever need (Bonnington, 2015; Economist, 2015), and for the developing world, this will be especially true. Much as some countries skipped copper wire, dedicated land line telephony infrastructures and

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http://dx.doi.org/10.1016/j.futures.2016.06.006
0016-3287/

jumped directly to mobile phone networks, many individuals now have the opportunity to skip the PC entirely and have as their first computer the smartphone, in capability, surpassing the power of a high end PC from just 10 years ago.

With the increased portability and personalization these devices offer the consumer have also come other fundamental changes. In many cases, end user products have reached a point where continual improvement of software-based features can occur on a daily basis without user intervention, the notion of "evergreen" web browsers, for example, that are always up to date with the latest standards (Techopedia, 2015). Rather than actively purchasing new products to upgrade one's technology, potentially a cumbersome process, software operating systems, apps, and web browsers can now "silently" receive updates to patch security vulnerabilities, for example, without the need for user intervention (Duebendorfer & Frei, 2009). Even modern automobiles, such as the Tesla, receive automatic software updates (Greengard, 2015).

In the area of assistive technologies for those with disabilities, products such as Apple's iPhone regularly receive updates that may fix accessibility bugs or add new features, though the "silent" model of updating has lagged for these users; some user intervention may still be needed to download and install the update. But even with the potential inconvenience posed by the user intervention, the fact that most operating system software and many application updates arrive at no further cost to the user is an improvement when compared to maintenance and upgrade fees charged by some assistive technology vendors on the traditional PC platform.

Thus technological change is moving us from one requiring active adoption of new products or capabilities to one where change is a given, even expected as an underlying baseline feature, as is the potential expectation that there will be constant improvement in the technologies we use. Will this model uniformly flow through to the world of assistive technologies? And more importantly as assistive features become more personal and personalized, what will be the impact for individuals with disabilities? While this model, and resultant expectations, are a positive development, there is evidence of some products becoming "orphaned" when a vendor ends support, often without the end user being made aware (Miller, 2013). It will be important to understand the risk of orphaning and how product futures are communicated to end users.

We can gauge potential changes and their impact on individuals in the future by recognizing key transitions from one technology to another and how those transitions bring, somewhere on a continuum, either success through significant change that improves quality of life, through to what might be considered a failure by cementing of a status quo, or worse, reduction in a capability. When a technology is successful, competition can arise with the development and availability of similar products with similar, but not necessarily equal capabilities. As assistive technologies or capabilities become ubiquitous, consumers will have ready access to off the shelf devices that can support their specific requirements. For many, access can then become self directed rather than mediated through assistive technology specialists. Building reliance upon consumer technologies to solve access challenges (physical/sensory), while providing a new level of independence, may in fact result in a user becoming dependent and less likely to receive what might be termed expert advice and guidance on what works best at the moment, and in future iterations of technology. With an emerging vendor diversity of similar products, there will come opportunities for failure to meet the needs of the user, either through intentional restriction of capabilities, restricted access to updated features, introduction of software bugs or security vulnerabilities, or through orphaning of products (Degusta, 2011).

## 2. Enabling access

There are several key technical developments, becoming ubiquitous, that are enabling a range of new assistive technology features within mainstream products, such as smartphones. To understand the complete picture of how individuals with disabilities are impacted, we will take a brief look at these developments.

First, let's put these developments in the perspective of assistive technologies. By definition (ATIA, 2015):

*"Assistive technology (often abbreviated as AT) is any item, piece of equipment, software or product system that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities."*

Smartphones, for example, provide a variety of methods by which functional capabilities of individuals can be increased, maintained, or improved. Accessibility settings are now common across a range of products from different vendors (see Fig. 1). Built in features now include screen readers, screen magnification, color contrast adjustments, speech recognition, and switch access. While these features owe their heritage and technical foundations to assistive technology originally pioneered for personal computers in the 1980's and 1990's, the design of smartphones has led to innovations, such as the use of touch gestures to control a screen reader. Beyond built-in assistive features, low cost and sometimes free third-party apps provide functions including camera-based magnification, augmentative communication, and specialized tools for a range of disabilities. Even televisions include built-in accessibility, moving beyond the already required closed captioning and secondary audio, with screen reading capabilities and control through spoken commands.

Beyond these explicit assistive features, the devices themselves contain important enabling technologies including multiple cameras, microphones, accelerometers, compass, GPS, light and proximity sensors, barometers, vibratory (haptic) feedback, Bluetooth connectivity, WiFi, and Near Field Communications (NFC). Combining any one of these core features with software opens the door to a range of fascinating new opportunities and ways to assist individuals with disabilities. For

Please cite this article in press as: H.T. Sullivan, S. Sahasrabudhe, Envisioning inclusive futures: Technology-based assistive sensory and action substitution, Futures (2016), http://dx.doi.org/10.1016/j.futures.2016.06.006