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The interaction experiences of visually impaired people with assistive technology: A case study of smartphones

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ABSTRACT

Globally, the number of visually impaired people is large and increasing. Many assistive technologies are being developed to help visually impaired people, because they still have difficulty accessing assistive technologies that have been developed from a technology-driven perspective. This study applied a user-centered perspective to get different and hopefully deeper understanding of the interaction experiences. More specifically, this study focused on identifying the unique interaction experiences of visually impaired people when they use a camera application on a smartphone. Twenty participants conducted usability testing using the retrospective think aloud technique. The unique interaction experiences of visually impaired people with the camera application, and relevant implications for designing assistive technologies were analyzed.

Relevance to industry: The considerations for conducting usability testing and the results of this study are expected to contribute to the design and evaluation of new assistive technologies based on smartphones.

1. Introduction

Worldwide, more than 285 million people are estimated to be visually impaired and 39 million of them are blind (WHO, 2013). The number of visually impaired people is continuously increasing owing to aging population, and in 2013, 82% of blind people were more than 50 years old. Visual impairment has a significant influence on peoples' daily lives, especially totally blind people who lose almost 85% of their ability to perform activities of daily living (Colenbrander, 2003).

Visual impairment, a deficiency of visual sensory processing, is defined as a best corrected visual acuity of less than 6/18 (WHO, 2010). It cannot be corrected using usual means such as standard glasses, contact lenses, medicine, or surgery. Visually impaired people face many challenges, and assistive technology helps them overcome these challenges. Assistive technology is an umbrella term for equipment, product system, hardware, software or service that increases accessibility for an individual (ISO/IEC, 2009, 2001). It is used for people with disabilities to support body functions and to prevent any activity limitations or participation restrictions (ISO, 2011). Fig. 1 introduces the conceptual diagram of assistive technology. People with disabilities can communicate with other people, devices and environments by interacting with assistive technology. Consequently, it enables people with disabilities to perform their daily living activities independently and to experience an improved quality of life. Various types of assistive technologies for visually impaired people exist in the market (Pal et al., 2011), and new assistive technologies for visually impaired people are being actively developed with mobile devices (Hakobyan et al., 2013).

However, visually impaired people complain of barriers to access assistive technologies (Kane et al., 2009; Oliveira et al., 2011) and there several diverse factors cause these barriers to exist. One of the most noticeable causes is that some assistive technologies have been developed with technology-driven perspectives, focusing on providing new and innovative assistive technologies. In the past, some researchers asserted that disabled people should adapt to the assistive technology (i.e., training with the help of

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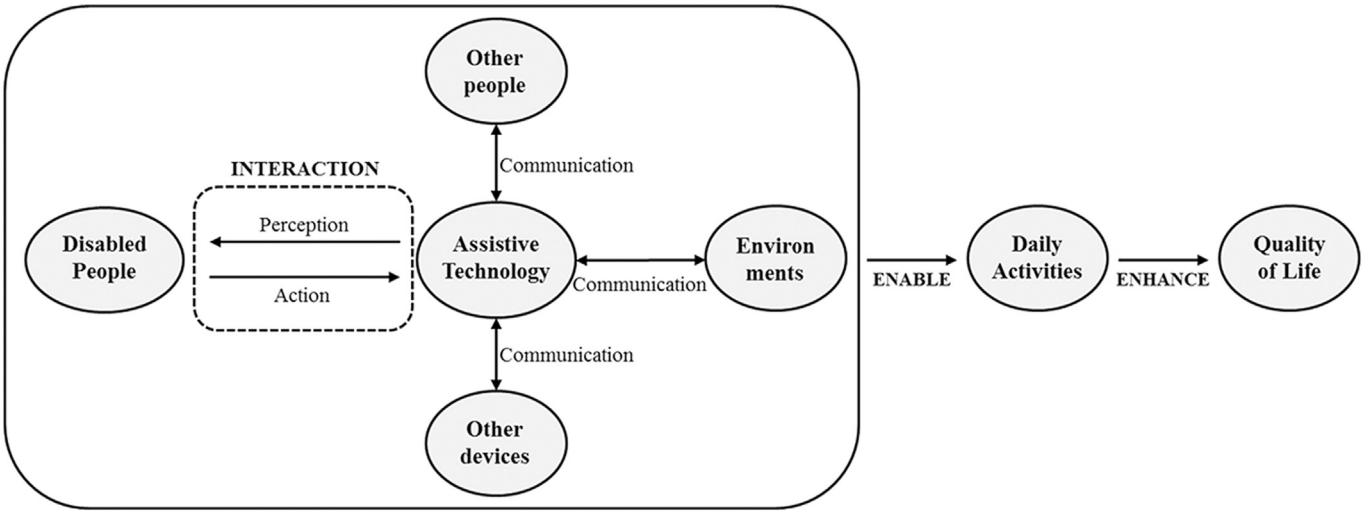

Fig. 1. Conceptual diagram of assistive technology.

assistive technology specialists or caregivers), instead of the technology being adapted to the users (Kintsch and DePaula, 2002). Fortunately, many researchers have recently started to emphasize the user-centered perspective for developing simple, easily accessible and user-friendly assistive technology (Abascal and Nicolle, 2005; Persad et al., 2007; Plos et al., 2012; Sutcliffe et al., 2003; Wobbrock et al., 2011). The fundamental concept of the user-centered perspective is to fully understand the users' needs; from this understanding, users are enabled to have satisfactory experiences with assistive technology.

The goal of this study was to understand the unique experiences that visually impaired people have while interacting with assistive technologies and to identify a possible gap between the ideas of designers of assistive technologies and the needs of visually impaired people from a user-centered perspective. To meet these purposes, a camera application for a smartphone was developed for visually impaired people. Usability of the new application was evaluated by conducting benchmark testing using the retrospective think-aloud technique. Four unique interaction experiences were observed from the usability testing and five implications for designing assistive technologies were analyzed.

2. Assistive technology and the role of smartphones for visually impaired people

Assistive technology for visually impaired people has been developed actively and its form ranges from simple (e.g., walking cane, magnifier) to relatively complex (e.g., navigation system, braille display) (Pal et al., 2011). The key assistive technology for visually impaired people can be categorized into three: mobility aids, the use of information/communication technology (ICT), and the control of environment (Hakobyan et al., 2013; ISO, 2011).

Assistive technology for mobility aids supports tasks that are related to orientation and navigation. Undoubtedly, lack of independent and safe mobility is one of the most severe barriers for visually impaired people in their daily life (Fallah et al., 2013; Paredes et al., 2013). Tasks related to mobility demand the ability to combine diverse spatial information (e.g., movement, perspective, depth and spatial organization of objects), which is mostly acquired by the visual sense (Strumillo, 2010). Hence, many trials have been attempted to combine diverse spatial information and to provide it to substitute sensory modalities (e.g., auditory, tactile) (Li et al., 2015). White canes or tactile sticks are the most widely used devices for mobility because of their simple, cheap and reliable features (Dakopoulos and Bourbakis, 2010). Recently, many researchers have started to develop IT-based devices to enlarge their functions to path recommendation (Faria et al., 2010; Ju et al., 2009), object recognition (Takizawa et al., 2012) and obstacle avoidance (Calder, 2010). Technology for detecting others' emotions by recognizing facial expression was also developed to help visually impaired people communicate with others (Astler et al., 2011).

Assistive technology for the use of ICT assists a person to perceive, send, produce, and process diverse forms of information on an ICT device (ISO, 2011). Remarkable assistive technologies to access ICT devices have been developed, which change visual information to auditory or tactile format, and vice versa; screen readers, speech recognition tools, Braille keyboards, Braille printers, and Braille displays are examples (Hochheiser and Lazar, 2010; Pal et al., 2011). Additionally, accessibility guidelines for the web or mobile applications are continuously being developed in many organizations and companies for improving accessibility on ICT devices (Harper and Chen, 2012; Piccolo et al., 2011; Vigo and Brajnik, 2011).

Assistive technology for controlling an environment, a smart home concept, is a relatively recent research topic in the assistive technology field (Hakobyan et al., 2013). A smart home connects all home systems, including home appliances, audiovisual and entertainment equipment (Vergados, 2010). Within interconnectivity of environments, visually impaired people can control all home systems remotely, and can get error or status messages on a personal mobile controller (Nicolau et al., 2010).

Nowadays, smartphones present opportunities to deliver these assistive technologies effectively for visually impaired people (Billi et al., 2010). For delivering the assistive technologies for mobility aids, a smartphone plays a major role in recognizing diverse objects using a smartphone's camera (Ko et al., 2011; Taylor et al., 2012), or in perceiving the current location from GPS sensors (Behmer and Knox, 2010). In the case of assistive technology for the use of smartphones, the development of screen-reading software on the smartphone (e.g., VoiceOver on the iPhone, TalkBack on the Android platform) has dramatically increased the accessibility of smartphones for visually impaired people (Brady et al., 2013; Harada et al., 2013; Oliveira et al., 2011). Regarding to a smart home concept, not many assistive technology has been developed along with the advancement in smartphones. A smartphone may function as the device for indoor navigation by detecting RFID tags