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Comparison of four different mobile devices for measuring heart rate and ECG with respect to aspects of usability and acceptance by older people

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ABSTRACT

In the area of product design and usability, most products are developed for the mass-market by technically oriented designers and developers for use by persons who themselves are also technically adept by today's standards. The demands of older people are commonly not given sufficient consideration within the early developmental process.

In the present study, the usability and acceptability of four different devices meant to be worn for the measurement of heart rate or ECG were analyzed on the basis of qualitative subjective user ratings and structured interviews of twelve older participants. The data suggest that there was a relatively high acceptance concerning these belts by older adults but none of the four harnesses was completely usable. Especially problematic to the point of limiting satisfaction among older subjects were problems encountered while adjusting the length of the belt and/or closing the locking mechanism. The two devices intended for dedicated heart rate recording yielded the highest user ratings for design, and were clearly preferred for extended wearing time. Yet for all the devices participants identified several important deficiencies in their design, as well as suggestions for improvement. We conclude that the creation of an acceptable monitoring device for older persons requires designers and developers to consider the special demands and abilities of the target group.

1. Introduction

The SmartSenior project is aimed at maintaining a high standard of autonomous living for senior citizens by developing new technologies designed to support their continued independence. One focus is the measurement and management of key medical data sufficient to serve as the basis for telemetric medical care and support services, yet with minimal intrusion into the person's daily life. Therefore a modular 24 h home monitoring device with integrated sensors is developed by Siemens AG. The system will contain ECG-sensors integrated in a belt and an ear-sensor measuring oxygen saturation and respiratory frequency. Within the user design process usability studies for SmartSenior devices are being methodologically designed by the department User Interface Design of Siemens Corporate Technology. Gathering and evaluation of data was conducted by the Geriatrics Research Group, Charité.

1.1. Usability aspects for older people

Usability problems and lack of acceptance often arise when a product is used by persons outside of the original target group. This is particularly evident when older people interface with newer technologies. Most aspects of the ageing process and its effects on the health status are known but there is only little knowledge about the special needs and demands of older adults when using technical and medical devices. Therefore seniors generally have to use products developed for a younger mass-market (Kaufman et al., 2003). The design of clothing styles for example results in difficulties to put on or move in, what effects an exceptional hindrance to an elderly person (Richards, 1981). This accentuates the fact that elderly persons have very unique and identifiable needs. A product-design for all approaches often fail, because of the individual anthropometry characteristics each person shows (Kothiyal and Tettey, 2001) Sandhu (1993) emphasizes the fact that attentiveness to basic human cognitive and sensorimotor abilities can significantly improve functional access to domestic appliances. Both manufacturers and consumers stand to benefit by markets enlarged by a statistically growing number of older persons defined

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by special needs and abilities Rigorous analysis of their needs and abilities during the early stages of product design can be expected to yield superior products for the elderly with a higher degree of consumer satisfaction.

Demiris et al. (2004) note in their review that in many projected smart home technology products are developed within experimental environments not designed to reflect the functional limitations and health care needs of older adults. The reviewed studies focus upon the use of sensors and devices but do not take into consideration the sustainability and acceptance of the older adults.

1.2. Personal health systems

Against the background of the demographic increase in the number of people over age 65, the quantity of older patients with chronic diseases is proportionately also rising (Haustein and Mischke, 2011). Chronic disease at first diminishes, and then eliminates, the functional reserve of an organ system, making early detection and intervention of higher critical importance than would be commonly the case with younger individuals. Personal health systems make such early intervention possible, with the potential to reduce not only the number of visits to physicians but also the frequency and duration of hospitalizations (Merilahti et al., 2009). One approach to achieving this goal is the continuous monitoring of vital signs, an important element of many personal health systems. Among the available options is the electrocardiogram, a comparatively simple, non-invasive method for the detection of cardiovascular disease and adverse events. The electrocardiograph (ECG) records the electrical voltage of the heart in form of a continuous strip graph and occupies a well established position in the detection of cardiovascular disease. Most ECG devices and their associated information systems, however, are developed for hospital usage rather than for everyday life (Shih et al., 2010; Lorenz and Oppermann, 2009). Muhlsteff et al. (2004) characterize the design of most currently available ECG systems as quite clumsy and uncomfortable for long-term use with no reference to the end-user viewpoint. This leads to a need for better usability relating to tools for telehealth (Koch, 2006).

Kothiyal and Tettey (2001) confirm an individual anthropometric variance in the elderly, which is representing the importance of an individual design especially for devices and tools concerning the elder generation.

Patient acceptance of personal health systems was evaluated by Dias et al. (2009), in a qualitative study with 7 subjects designed to identify usability and handling problems associated with a heart rate monitor and two activity sensors. They concluded that wearing the heart rate sensor for only a few hours was uncomfortable and produces skin irritation as a result of the need for secure adhesion of the electrodes to the skin of the chest wall in order to obtain a satisfactorily usable signal. The functionality of the device was not evaluated, although this aspect was investigated in several. prior studies, which addressed issues of the robustness and tracing quality among various heart rate monitors and mobile ECG systems (Weippert et al., 2010; Kingsley et al., 2005). The concluding body of evidence suggests that sensors have the ability to provide reliable and objective data concerning the health status of chronically ill patients in everyday life, but that the successful introduction of such sensors still presents usability and technical challenges for the manufacturers (Dias et al., 2009). Patient acceptance remains an essential criterion for that success to be realized (Fensli et al., 2010) and the demand for more studies to identify the design factors contributory to good compliance which contribute to high compliance continues to be voiced (Merilahti et al., 2009).

1.3. Present study/aim

The SmartSenior project proposes to develop a personal health system for the capture of health data in a modular fashion. The modules would include – but not necessarily be limited to – measurements of heart rate, body temperature, O2 saturation, respiratory rate and perspiration, as well as the optional recording of the patient's ECG, blood pressure and blood sugar. The system allows a standardized transmission of vital parameters as well as extended transmission of vital data coordinated with emergency assistance and intervention. The current study was intended to evaluate the usability of two heart rate monitors and two mobile ECG devices in order to identify important aspects for acceptance and usability of a long term monitoring system by older people. The physical manipulation of the belts for these devices – attachment to the chest, adjustment of tension and use of the locking mechanism – was one of the principal objects of study, as well as issues of comfort. The study should determine, if currently available mobile devices for heart rate and ECG refer to the special needs of older adults. The intent would be to incorporate these findings directly into the development process of the proposed modular health monitoring system.

2. Method

2.1. Experimental design

The study was conducted by the Geriatrics Research Group, Charité – Universitätsmedizin Berlin in collaboration with Siemens AG Corporate Technology as a prospectively-designed, randomized and monocentric study. The study was approved by the ethic committee of the Charité – Universitätsmedizin Berlin.

2.2. Participants

Twelve participants were recruited for the study (4 female; 8 male; mean age 71 yrs; age range: 55–90 yrs) from the hospital and the sport health park of the Evangelisches Geriatriezentrum Berlin (EGZB). An attempt was made to recruit a sample of participants representing the most likely potential end users of the system with respect to age and disease spectrum. Individual mobility limitations were additionally documented. None of the participants had previously used a heart rate or ECG belt. The sample size was comparable to similar earlier studies (Dias et al., 2009; Demiris et al., 2004) and typically acceptable for qualitative research.

2.3. Experimental measures

Evaluation of usability was determined by a combination of subjective user rankings and independent observer measurements. These included:

- a structured interview, in which participants were systematically questioned regarding the handling and acceptability of the different belts, with the attempt to solicit suggestions for improvements regarding CMF (colour, material, finish).
- evaluation by an expert (an experienced physiotherapist), who documented the nature and severity of difficulty the participants demonstrated while handling the belts. Documentation included the time take to perform specific tasks as well as the frequency and extent of any adverse events, particularly skin irritation.
- use of a questionnaire, through which the subjective opinion of each participant was elicited with respect to preferences among the test items (semant, Differential).