Perceived Usefulness among Elderly People: Experiences and Lessons Learned during the Evaluation of a Wrist Device

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***Abstract*—In this paper, we present and discuss the evaluation of end user acceptance of a wrist device, designed to monitor vital signs and to detect adverse situations, such as falls, unconsciousness etc. and, if necessary, to alert emergency services to the wearers need. The goals of all concerned must be taken into account if the technological advances are to be of benefit to those for whom they are being designed. After the technical assessment was made, a further study of the end users views was aimed to show the acceptance levels of elderly end users to the idea of personal monitoring, its perceived usefulness in their every day lives, and their judgment of the design. This was made in the form of a questionnaire divided into five main areas: usefulness, attractiveness, usability, comfort and acceptance, and each end user was interviewed regarding their goals. Each of the interviewees regarded their own continuing independence as a primary goal; however their views as to the possibility of achieving this goal by the use of advanced technology differed. This work was completed as part of the EMERGE project, aimed at the support of elderly people in everyday life using innovative monitoring and assistance systems, with the use of ambient and unobtrusive sensors in order to increase their safety, thereby promoting a longer period of independence, a step made necessary by the demographic increase in the elderly population in Europe.**

Keywords: Evalution, Acceptance, Usability, Aging, HCI, Elderly,

I. INTRODUCTION

While the dangers of increased heart rate in old age have been known for some time (e.g. [1]), the elderly are often less willing to trust technological devices than medical personnel. However, in order to minimize risk, a continuous monitoring of the pulse or heart rate – with the possibility of acquiring immediate aid if needed – is more effective than periodic observation. At the same time it is recognized that falls are more serious in the elderly [2] and that a speedy response to a medical emergency greatly increases the chance of recovery. The current demographic trend [3] makes it extremely unlikely that constant care of the elderly will be possible without some form of institutionalization, unless a technological solution can be offered, accepted and exploited [4].

Currently, a number of devices are commercially available, which offer either pulse control, fall detection or emergency services.

Art of Technology AG (AoT) of Switzerland has designed and engineered an automatic monitoring device that incorporates a number of these functions into a single wrist device. Weighing little and worn as watch, it continuously transmits data to a base station and, if necessary, transmits a call for help, without adversely affecting a person's mobility thereby greatly increasing the ability of the wearer to continue to lead an active life.

The suitability of a Wrist Device for measuring the Vital Signs of an elderly or infirm person is dependent on a number of criteria. The purely practical considerations include: Safety; Reliability; Accuracy; Controllability and Compatibility.

While the acceptability aspects, such as weight; comfort and trust ensure wear-ability and continued use, the elderly must be willing to judge innovations on their merits rather than rejecting them out of hand. Awareness and acceptance can be fostered and increased by both education and example [5], [6].

While a technical evaluation of the functionality and error recognition was made, a parallel evaluation on the part of the end users was effected. The aim was an analysis and assessment, according to pre-set criteria (e.g. [7]) of a range of possible applications and an analysis of the effects achieved with the system during the interaction with people.

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II. METHODOLOGY

A. Hardware

The EMERGE Wrist Device (WD) is worn on the wrist (see figure 1), since it also shows the time, consequently it can replace a wrist watch. Vital data measured by the device is forwarded using Zigbee Wireless protocol to the base station where it is received, logged and forwarded by UDP to applications for analysis and alarm processing. For evaluation and demonstration purposes the gathered data is visualized in the EMERGE WD viewer featuring thematic graphs.

Parameters and algorithms in the WD have been set up to trigger events given particular data combinations. For example: When acceleration and pulse data indicate a possible fall, an alarm protocol is initiated. In the test environment, the base station was a computer with Windows™ system software, and a Zigbee-Stick. The WD has an internal, rechargeable battery that can be charged over any USB port of a Computer/Laptop or corresponding power supply. The heat tolerance has not been completely verified; however, since the device is worn on the arm, the anticipated temperature range will be minimal. The actual weight of the device is 46g.

Figure 1: A close up of the WD

B. Technical Evaluation

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Basically, evaluation is not merely the examination of the function or error recognition. The aim is an analysis and assessment of all possible applications and an analysis of the effects achieved with the system during the interaction with people. The purely practical considerations include: safety; reliability; accuracy; controllability and compatibility. By combining the EMERGE Wrist Device with comparable commercial devices for measuring heart rate and temperature, while simulating various emergency situations, it was possible to evaluate these attributes. The information transferred to the monitoring station was logged to later comparison to the reading received on the wrist device and the hand-logged simulation data (time of falling, length of non-movement etc.). These steps conformed to the first 3 steps of the evaluation plan: i) Comparison of pulse rate readings with a standard commercial device by the evaluation team. ii) Verification of data transmission between the wrist device and the base-station. iii) Objective test of functionality while worn by non-medical participants. The resulting data enabled an objective evaluation of this single component; however, it gave no information as to the probability of its use by the end users, for whose benefit it was designed. For this, it was necessary to complete steps 4 & 5: iv) A subjective test of acceptability and usefulness in the form of a questionnaire followed by v) interviews with members of the target age group. The final report was a complete assessment of the data collected in these 5 steps.

C. Usability Evaluation

Questions of usability, acceptance, user experience etc. are difficult to assess at this point due to the early prototype status of this device, therefore the end user questionnaire was completed during an informal meeting with a social group of elderly people during an informal evening and following discussion was kept as relaxed and impersonal as possible. The aims of the EMERGE group were explained and the purpose of the Wrist Device presented. Since the WD was a prototype, the questions posed dealt with subjective values: Usefulness [8], [9]; Attractiveness [10]; Usability [6]; Comfort and Acceptance [11], [12].

Participants in the usability testing were of various ages. An equal distribution of people in each age group was not realistic. While no minimum age was required for the technical evaluation, since this was not a factor, a minimum age for our target group was set at 55. However, two of the technical evaluation participants, both of whom were under the minimum age, wished to document points that had attracted their attention, and therefore completed the questionnaire.

The questionnaire is divided into five main areas: usefulness, attractiveness, usability, comfort and acceptance. Each of the 23 statements can be confirmed or denied with a 6 point Likert scale: 1: disagree strongly; 2: disagree; 3: tending towards no; 4: tending towards yes; 5: agree; 6: agree strongly. In each of the five groups one or more of the statements were negated to weed out any *agree with everything* actions. A six point Likert was used to avoid the *evasive middle* action, instead the participants were told that if they felt unable to answer any of the questions they should leave these blank. This enabled us to achieve a more accurate subjective response from the participants, untainted by "*don't know so I'll just put a tick somewhere in the middle*" answers. The questions were then randomly resorted and printed in both English and German. After the completion of each questionnaire, the end user was interviewed.

III. RESULTS

A. Functionality

The wrist device combines a number of functions, some of which are available commercially, none of which are available in a single device which can be worn continuously. The connection of the Wrist Device to a central computer capable of reacting to an alarm is accurate and reliable.

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However, the currently used USB-ZIGBEE connection/USB WD recharger combination is not ideal since they interfere with each other, and few elderly people own two PCs. As a prototype connection it is successful, for a permanent installation, a number of ZIGBEE sensors will be necessary and a charge system which does not require the wearer to remove the WD for any length of time. The fall detection was successful and the alarm information relayed to the software immediately. However, the testers were disturbed by the fact that they were unable to deactivate an alarm if this was accidental, for example: if the WD fell behind a large piece of furniture as a few minutes were required for its recovery during which time no movement of heart beat would be detected. Special care should therefore be taken in the design of an interactive interface to insure its intuitiveness for elderly users.

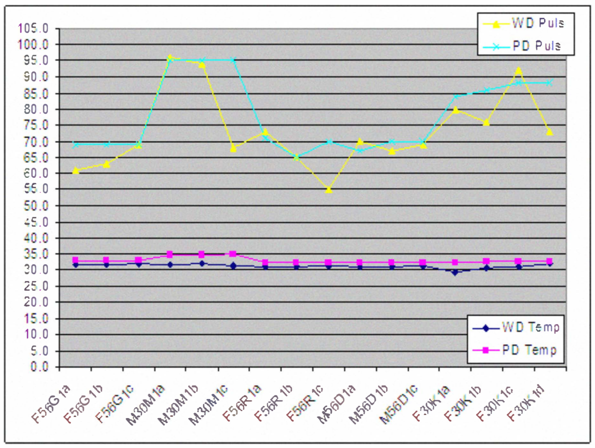

Figure 2: Comparison of temp. measurements

Since the PULSE measurement only takes place when the skin temperature registers as above 30°C (wearer detected), the chart (figure 2) above shows the registered temperature at each pulse reading below the registered pulse measurements. All values shown on the charts as WD measurements were acquired by means of log files and confirmed by comparison with manual notes.

B. Helplessness Detection Principle

The WD (see figure 3) supervises the movement of the wearer in order to detect helplessness, caused by circumstances such as a fall or other reasons. Therefore, the watch uses the following measures for providing information and alarms:

- Movement measurement in all 3 dimensions, and overall for activity, measurements transmitted regularly
- Impact recognition followed by a period of no movement raises a fall alarm
- No movement over a longer period raises no movement alarm

Using the above strategy, the WD handles the challenge of recognizing every fall while avoiding false alarms. Falls to the floor can be very slow and without recognizable impact or more in a forward direction than straight down to the floor. Thus, even when a fall is not immediately recognized as an impact, a no movement alarm is raised if the person is helpless. Whereas if the person stands up immediately after the fall, no alarm is sent out.

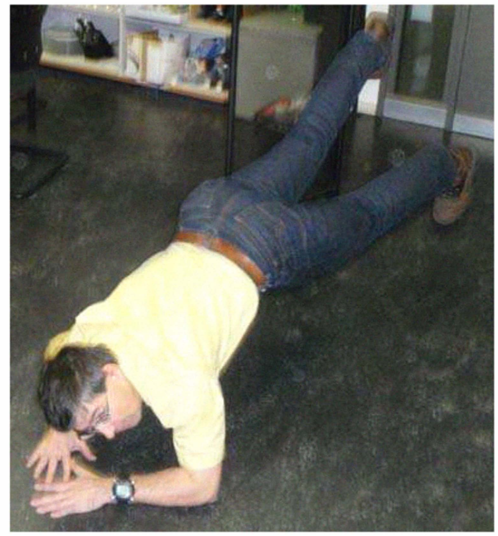

Figure 3: The problematical forward fall

C. Helplessness Detection Results

The testing of impact recognition is achieved by letting the WD fall from a height of 20 to 50cm into a box of small packing material to avoid the WD jumping after the impact. This rather technical test showed 100% recognition of impact as summarized in Table 1.

Validation of fall is limited to artificial falls either using martial art techniques or a thick mat to avoid injuries. Martial Arts techniques were used for falls forward, sideways and backwards. These tests showed good recognition for the sideways and backward falls, however the forward falls were less successful as the movements involved were too artificial (see figure 3). Nevertheless, even in the case of the fall not registering as such, a no movement alarm is sent out in case of any helplessness.

TABLE I. HELPLESSNESS TEST SUMMARY ONTO HARD FLOOR

Test Setup	# performed	# positive	% positive
Fall of Watch	9	9	100.00
Sideways Fall	1	1	100.00
Forward Fall	4	1	25.00
Forward Roll	1	1	100.00
Backward Fall	1	1	100.00
Slowly Downwards	1	1	100.00
No Movement	7	7	100.00

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D. *Questionnaire*

The first section of the questionnaire dealt with the perceived **Usefulness** of the Wrist device and contained four statements, two positive and two negative.

TABLE II. ALARM SYSTEM COULD SAVE LIVES

	Frequency	%	Valid Percent	Cumulative Percent
tending towards no	1	7,1	7,1	7,1
tending towards yes	2	14,3	14,3	21,4
agree	4	28,6	28,6	50
agree strongly	7	50	50	100
Gesamt	14	100	100	

The replies showed that while 92.9 % of the participants agreed that an alarm system could save lives (Table 1), they leaned towards the belief that it would probably only be needed by people with heart problems (ap:4.46) and that restricting its usage to the home would lower its usefulness (ap:4.69)

Only 42.8% of the participants, considered the functions of the tested alarm system useful (Table 2).

TABLE III. CONSIDER THE FUNCTIONAL USEFUL

	Frequency	%	Valid Percent	Cumulative Percent
disagree strongly	2	14,3	18,2	18,2
tending towards no	3	21,4	27,3	45,5
tending towards yes	1	7,1	9,1	54,5
agree	4	28,6	36,4	90,9
agree strongly	1	7,1	9,1	100
Gesamt	11	78,6	100	

The second section dealt with **Attractiveness** and received a total average point of 3.2. Since this was actually a prototype, we were not looking for a high evaluation but for the comments received in the post-questionnaire discussion, which confirmed the need for a light, unobtrusive device, preferably in different colours.

The question of **Usability** has a great deal of influence on the level of acceptance, consequently these issues must be considered at an engineering level [13]. The basic measures included: **intuitive** usage; **easy-to-use** buttons; **simplicity** of texts; **autonomous** control and usage without special (medical) **training**.

Since the total note given by the end users was a straight-down-the-middle 3.5, it is worth looking closer at the individual notes. While they were fairly happy with the texts and confident that they would be able to learn to use it, they found the buttons difficult to use and by no means intuitive. This is also reflected in the results of the Acceptance section, where their willingness to buy the wrist device for someone else exceeded their willingness to buy one for themselves: 57.1% of the participants would buy it for someone else and 49.9% of the participants would like it as a present

TABLE IV. PREFERENCE: PERCHASE VERSUS PRESENT

	I would buy it for someone else	I would like to receive it as a present
tending towards yes	21.4%	35.7%
agree	14.3%	7.1%
agree strongly	21.4%	7.1%
Gesamt Percentage	57.1	49.9

There was an almost unanimous agreement (one dissenter) that the wrist device was more **Comfortable** to wear than comparable devices and preferable to devices requiring a chest band.

E. *Interviews*

After the completion of the questionnaires, some of the comments written in the margins of the questionnaires led to general comments, which in turn led to the participants being informally interviewed.

While the interviews were aimed at getting feedback about the probability of the group ever accepting this type of technology enough to actually use it, care had to be taken in the phrasing since it had taken quite some time to persuade them that it was their opinions I wanted and that I was not selling anything.

In the end, the main topic was: what would you have done differently? While there was a consensus on certain aspects of the design, such as the contrast of the display: "*Dark grey text-on light grey background-is very difficult to read*", and the possible necessity of being able to adjust the size of the text "*in case I am not wearing my glasses*" a few questioned the actual concept of a **wrist** device. As one elderly lady put it "*If I wear it on my wrist, I'll have to take it off to wash up*".

After this, suggestions for alternatives were made and questions of practicability asked. A few wanted to know whether a "sort of" pendant on a chain could be used if worn next to the skin and one gentleman suggested fixing it to his hearing aid.

The manual alarm button tended to stick, requiring more pressure to activate than is consistent with an elderly person in need of help. (Note: It is recognised that this is a prototype and that this will not be a problem in the final design).

There was some question as to the applicability of a device, which was only useful near a monitoring station and whether any plans were being made to extend the range.

Questioned on the reasons for their willingness to purchase the Wrist device for someone else, but their unwillingness to use one themselves, the answers – surprisingly – were less to do with a reluctance to be monitored and more to do with an unwillingness to concede the need. While the men felt that they had no need for one, 60% of the women agreed that, if they needed one, they would need it outside the home.

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IV. CONCLUSION

The wrist device successfully combines a number of functions, some of which are available commercially, none of which are available in a single device which can be worn continuously. The software used to connect the Wrist Device to a central computer capable of reacting to an alarm is accurate and reliable, however restrictive since it is necessary for the wearer to be in range. However, these restrictions are known and a marketable version of the prototype would of necessity have addressed them.

The fall detection was successful and the alarm information relayed to the software immediately. However, the testers were disturbed by the fact that they were unable to cancel a wrong alarm. The objection being that, should the wrist device have been dropped, perhaps behind a heavy piece of furniture, rather than the wearer falling, they would be unable to cancel the alarm. The deactivation of alarms will be added to the base station. There was some difficulty with the pulse measurement, which failed to agree exactly with the comparison devices possible due to the amount of movement. The testers also expressed some doubt as to whether the 30°C level was sufficient, since the skin temperature of sedentary, elderly people tends to be lower than that of more active people. Taken in combination with the general lower skin temperature of females, this could cause a problem. The temperature parameter is adjustable and optimum settings will be investigated further.

The most surprising thing about the usability session was the participants' openness to technological solutions to possible problems, including monitoring, since this contrasted so clearly with previous experiences and research. The most likely reasons for this were that the group were all still relatively independent and living in their own homes; that they were interested enough to arrive at the meeting place under their own steam; the atmosphere was relaxed and not demanding or threatening.

The initial reluctance seemed to be caused by the natural distrust given to a stranger doing any type of research and particularly one that dealt with health and safety concerns. There was also the understandable suspicion, frequently observed among the elderly, that they may be pressured to purchase something they neither want nor can afford. The introduction was therefore to reassure them that no experimentation was planned, that we were not selling anything and that any information given to us would be completely anonymous.

While there was none of the expected reluctance towards the device, there was a definite reluctance to admit of any need for a monitoring device.

The interviews, along with the questionnaire responses, show that more investigation into the motives of the elderly for technology must be made, specifically, gender-based motivation. While it is true that less interest was taken by the male participants, the reasons could be simply that fewer men are required to care for elderly relatives or that men are less willing to admit to weakness or need. However, it is equally possible that the reasons are various and complicated.

Further investigation should be given to the importance of gender-related perception. The willingness to buy an emergency monitoring device for somebody else is a beginning.

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V. REFERENCES

[1] H. Tsuji, F. J. Venditti, E. S. Manders, J. C. Evans, M. G. Larson, C. L. Feldman, and D. Levy, "Reduced Heart-Rate-Variability and Mortality Risk in an Elderly Cohort - the Framingham Heart-Study," Circulation, vol. 90, pp. 878-883, 1994.

[2] J. Close, M. Ellis, R. Hooper, E. Glucksman, S. Jackson, and C. Swift, "Prevention of falls in the elderly trial (PROFET): a randomised controlled trial," Lancet, vol. 353, pp. 93-97, 1999.

[3] M. G. Parker and M. Thorslund, "Health trends in the elderly population: Getting better and getting worse," Gerontologist, vol. 47, pp. 150-158, 2007.

[4] N. Noury, J. Poujaud, and J. E. Lundy, "Multidimensional context analysis for recognition of health risk situations: The paradigm of fall detection," IRBM, vol. 30, pp. 268-272, 2009.

[5] A. Nischelwitzer, F.-J. Lenz, G. Searle, and A. Holzinger, "Some Aspects of the Development of Low-Cost Augmented Reality Learning Environments as examples for Future Interfaces in Technology Enhanced Learning," in Universal Access to Applications and Services. Lecture Notes in Computer Science (LNCS 4556). Berlin, Heidelberg, New York: Springer, 2007, pp. 728-737.

[6] A. Holzinger, G. Searle, T. Kleinberger, A. Seffah, and H. Javahery, "Investigating Usability Metrics for the Design and Development of Applications for the Elderly," in 11th International Conference on Computers Helping People with Special Needs, Lecture Notes in Computer Science LNCS 5105, K. Miesenberger, Ed. Heidelberg, Berlin, New York: Springer, 2008, pp. 98-105

[7] A. Holzinger, "Module 6 Assessment of Software: Evaluation (with assistance from Dawn E. Carmichael and Gig Searle)," in Multimedia Basics, Volume 3: Design (www.basiswissen-multimedia.at). New Delhi: Laxmi, 2005, pp. 231-266.

[8] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," MIS Quarterly vol. 13, pp. 319-339, 1989.

[9] T. K. Landauer, The Trouble with Computers: Usefulness, Usability and Productivity. Cambridge (MA): MIT Press, 1995.

[10] M. Schrepp, T. Held, and B. Laugwitz, "The influence of hedonic quality on the attractiveness of user interfaces of business management software," Interacting with Computers, vol. 18, pp. 1055-1069, 2006.

[11] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," MIS Quarterly, vol. 27, pp. 425-478, 2003.

[12] A. Holzinger, K. Schaupp, and W. Eder-Halbedl, "An Investigation on Acceptance of Ubiquitous Devices for the Elderly in an Geriatric Hospital Environment: using the Example of Person Tracking " in 11th International Conference on Computers Helping People with Special Needs, Lecture Notes in Computer Science (LNCS 5105). Heidelberg, Berlin, New York: Springer, 2008, pp. 22-29.

[13] A. Holzinger, "Usability Engineering for Software Developers," Communications of the ACM, vol. 48, pp. 71-74, 2005

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