# Persuasive Pillboxes: Improving Medication Adherence with Personal Digital Assistants

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**Abstract.** Personal digital assistants (PDAs) can be used persuasively to change attitudes regarding medication taking, thereby facilitating adherence for older adults. A pillbox that integrates onto the body of the PDA was created as a place to store mid-day pills. Results from a lab and field experiment on older adults' perceptions and use of PDAs for medication minding are reported. In both the lab and field experiment, older adults were successfully trained to use PDA standard programs and a program for medication reminding. At the conclusion of the 3-month field experiment, a physical pill count yielded increased compliance with two-thirds of the participants missing 1 pill or less in the third month of the study. Implications for PDA training curricula, hardware design, and future research are discussed.

## 1 Introduction

Medication-related problems represent a huge cost to the United States economy. Over $76 billion dollars (Johnson & Bootman, 1995) are spent annually on medical complications caused by not taking medication appropriately. Unfortunately, the cognitive and perceptual changes that co-occur with age make older adults susceptible to medication errors (Park & Jones, 1997). One approach to improving medication adherence is through the use of personal digital assistants (PDAs). The purpose of this paper is to describe how a PDA training program used in conjunction with specially designed software, like the RxReminder™ software described here, can change the attitudes of older adults to improve medication adherence. As our goal is to effect change in medication adherence behavior in a predetermined way, the use of PDAs in this fashion is certainly persuasive as defined by Fogg (1999).

### 1.1 Identifying and over Coming Barriers to Training and Usage

The realization of the potential benefits of PDAs is dependent on the attitudes and usability needs of this special population. For instance, if one does not possess a positive attitude in the utility of learning to use such a device, the PDA is not likely to

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be adopted to assist medication adherence tasks. It has been reported (Mayhorn, Lanzolla, Wogalter, & Watson, 2005) that older adults take longer to learn to use PDAs and commit more errors when entering information into a PDA-based medication software application. Efforts to overcome these behavioral and attitudinal barriers must include well–designed training targeted to older adults to teach PDA usage skills as well as creating software with improved interface and operation.

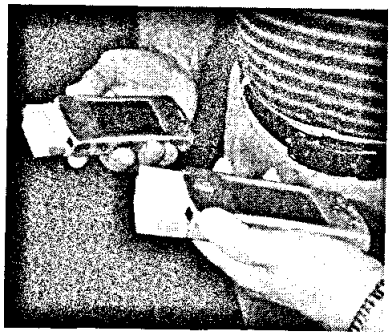

**Fig. 1.** The PDA Pillbox Prototype (patent pending) on the Samsung i300. The pillbox could hold a day's worth of pills, improved stylus access, and allowed wireless infrared transfer.

**Persuasive Software and Pillbox.** To increase the number of people who can benefit from the features a PDA can offer, the barriers to using the device must be addressed. Special usage skill training is required (Sterns, 2005) as well as creating software with improved interface and operation (Czaja & Lee, 2001) to improve the likelihood of success for the participants. RxReminder™ is a software application designed to meet these criteria. This reminder program is capable of showing pictures of drugs so that the shape, color, and markings of the pills can be clearly seen. It is also important to link the reminder program and the medications. To accomplish this task, Sterns designed a patented pillbox attachment that would integrate with the PDA to provide a way to carry mid-day medications or supplements (See Fig. 1).

## 2 Overview of Research

To systematically address the likelihood that older adults can learn to use PDAs to improve their medication adherence, two studies were conducted. In study 1, young and older participants were asked to complete a PDA-based medication entry task in the laboratory before completing a usability questionnaire that also assessed attitudes regarding PDA usage. This data provided "proof of concept" information regarding the PDA-trainability of older adults. Study 2 was conducted to determine whether lab-based results could be extended to the field during actual medication adherence.

### 2.1 Study 1 – Lab Evaluation of PDAs by Young and Old Adults

The purpose of the lab study was to determine perceived usability of PDAs by 26 young (Mean age of 18.6 years, SD = 1.36) and 25 older adults (mean age of 67.3 years, SD = 5.25). To supplement an experimental task that required participants to enter medication data into a commercially available PDA-based software application

(reported in Mayhorn, et al., 2005), participants were also required to complete a usability questionnaire. Perceived PDA usability was measured using six rating scales: (a) overall satisfaction, (b) simplicity of operation, (c) ease of medication information entry, (d) ease of learning, (e) error recovery, and (f) likelihood of future use. Participants rated their agreement to each rating statement using a seven-point Likert scale with anchors ranging from 7 "Strongly Agree" to 1 "Strongly Disagree." The goal was to determine whether age differences in perceived PDA usability are present following interaction with these devices and how changes in attitudes might influence the likelihood of future use. Thus, the persuasive aspects of PDA usage are being measured here.

**Usability Agreement Ratings.** The mean usability agreement ratings for each age group are shown in Table 1. For all items, the mean agreement rating was above 4.80, which indicates that each age group on average held positive attitudes regarding their first experience with PDAs. T-tests revealed age differences in perceived usability for five of the six statements. Younger adults rated the PDAs as significantly easier and simpler to use and rated the ease of learning to use the devices as higher than that reported by the older adults; $t(49) = 2.80$, $p < .01$, $t(49) = 3.42$, $p < .01$, and $t(49) = 2.46$, $p < .01$, respectively.

**Table 1.** Mean usability agreement ratings

| | Young | Older |
|---|---|---|
| Overall satisfaction | 6.42 | 5.72** |
| Simplicity of operation | 6.50 | 5.68** |
| Ease of learning | 6.46 | 5.92** |
| Error recovery | 6.31 | 4.80** |
| Likelihood of future use | 5.15 | 5.24 |

*Note.* $*p < .05$, $**p < .01$.

Although the performance data (reported in Mayhorn et al, 2005) revealed that older adults require more time to learn to use PDAs and make more errors than young adults, it should be noted that these errors declined with practice over time. Coupled with the perceived usability information reported here, older adults' difficulty using PDAs apparently does not translate into decreases in positive attitudes regarding their use. While these data illustrate that older adults can learn to use PDAs in the laboratory, the field experiment described next illustrates that these results can be generalized to improve medication adherence.

## 2.2 Study 2 – 3-Month Use Test with Older Adults

*Study Design.* Forty–four community–dwelling participants ranging in age from 56 to 89 (average age of 72 years) completed training; 90% of those recruited. Training procedures and results are documented in Sterns (2005). A physical count of the pills using a pharmacy tray was conducted for the participants at the beginning of the study

and at the end of each month for 3 months. Adherence of up to 2 prescriptions or 1 supplement was tracked. Participants took between 1 and 18 medications ($M$ = 3.8, $SD$ = 2.7) and over–the–counter supplements ($M$ = 3.5, $SD$ = 2.1) daily.

## 3 Results

*Medication Adherence Results.* The average missed pills were 1.04, 2.43, and .05 pills in months 1, 2, and 3 respectively. We found that 24 individuals, 57% of those counted in the third month of the study had perfect adherence and 28 individuals, 67% of those counted in the third month had missed no more then one pill. Eleven of twelve (92%) of those who took mid-day pills used the pillbox.

## 4 Discussion

Collectively, the results of both studies indicate that older adults can be trained to use PDAs and that these devices can be used to promote medication adherence in the field. Furthermore, findings indicate that older adults hold generally positive attitudes towards learning to use this new technology and that they found the devices to be usable when appropriate training was made available.

Future research might focus on further improving device usability for a number of other applications such as banking, communication, and warning systems. Through the use of iterative design methodologies, the specialized needs of older adults can be met. Such work should result in an increased likelihood of retaining independence and improving safety for community dwelling older adults.

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