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The computer literacy scale (CLS) for older adults – development and validation

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Abstract

An important prerequisite for successful usage of computer systems and other interactive technology is a basic understanding of the symbols and interaction patterns used in them. This aspect of the broader construct "computer literacy" is used as indicator in the computer literacy scale, which proved to be an economical, reliable and valid instrument for the assessment of computer literacy in older adults.

1 Introduction

Even though there is no generally agreed upon definition of computer literacy (Turner et al., 2000; Mason & MacMorrow, 2006), there is widespread acceptance of the fact that it has great impact on the ability to interact with computers: "Just as one needs to have reading literacy to benefit from the information made available by the printing press, one must have computer literacy to benefit from the information made available by the personal computer." (Poynton, 2004, p.862). Especially older adults often lack the necessary knowledge and motivation to use computer technology, even though they could benefit greatly from it. Inversely, it could be considered a characteristic of a technical device to require more or less computer literacy to use it effectively. Today, such devices are not limited to desktop or laptop computers, since computer technology is increasingly incorporated into other common goods, such as car navigation systems, smart phones, photo cameras or even refrigerators.

Even though there are a variety of computer literacy and related measures available (Beckers & Schmidt, 2003; Bozionelos, 2001; Garland & Noyes, 2004; Potosky & Bobko, 1998; Schumacher & Morahan-Martin, 2001; Smith et al., 2000; Smith et al., 2007; Turner et al., 2000; Wagener, 2003; Winter et al., 1997; Miller et al., 1997; Pyrczak, 1990; Potosky, 2007), none of them is short, objective and age specific for older adults, which led to the development of the CLS. This lack of instruments has also been found by Arning and Ziefle

(2008) for the assessment of computer expertise. Thus they created a computer expertise questionnaire (CE), which was used for validation of the CLS.

The CLS focuses on a small but essential aspect of computer literacy and uses it as indicator: If literacy can be considered the ability to read symbols and use them, then computer literacy could be considered the ability to understand and use computer related symbols, functional elements and interaction patterns.

2 The computer literacy scale (CLS)

The computer literacy scale (CLS) is an objective knowledge test assessing the basic understanding of symbols and terms commonly used in the user interface of interactive computer technology. It has been designed specifically for older adults with little computer knowledge and is based on the idea, that knowing common symbols and terms is as necessary to use computers, as it is to read (and write) books. Such computer literacy requires exposure to and experience with computers, but requires also active construction of knowledge, which is why experience should not be the same as literacy. People with high computer literacy should be able to interact well with computers and should recognize the “alphabet” of the computer user interface.

The CLS consists of 2 parts. Part A assesses experience with computers and contains 14 items, divided into the duration in years (1 item), the intensity in hours per week (1 item) and diversity as an estimate of the frequency of eleven different computer related tasks, five of which are specifically addressing Internet use.

Part B contains 26 items and assesses the computer literacy as knowledge of symbols (21 items +3 distractors) and terms (5 items +1 distractor) related to computers and other electronic equipment. Items are presented in a matching task with numbered descriptions. Figure 1 gives an example with seven items and one distractor. The complete CLS can be filled out online or downloaded in its current version from www.computer-literacy.net.

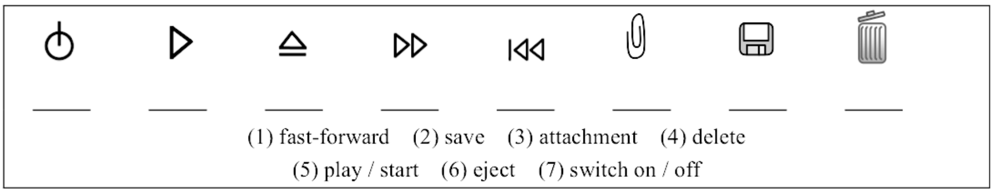

Figure 1: Example for items in the matching task of the CLS

Symbols, terms and descriptions were collected and checked by experts for comprehensibility. Translations from the German original into English and Chinese were done or checked for accuracy by native speakers.

The completion time ranged from 10-20 min, largely depending on the computer knowledge and ambition of the participant. Since the CLS was designed to be a power test, there was no time limit given. The instructions ask to answer all the questions and to guess when in doubt.

The scores are calculated as follows: Part A. For experience with computers, duration and intensity are metric values. Diversity is calculated as the sum of frequencies of the single tasks with never=0, seldom=1, sometimes=2 and often=3, leading to a maximum score of 12x3=36. This solution has two caveats: First, it is debatable, that the ordinal data of the scale is not equidistant and hence cannot be used for addition. The arguments that weigh the pros and cons and support the notion of cautiously treating ordinal data like metric data cannot be discussed here but some can be found in Labovitz (1970) and Rohrmann (1978). Second, summing the score implies that the tasks are equally important, which is not assumed to be the case. Rather, complex tasks such as programming should be more indicative of high computer literacy than simpler tasks such as word processing and emailing. However, the sum score for diversity could still be useful to complement the analysis of the individual tasks. Since many studies use only subjective measures of computer experience as control variables, they will be used for comparison to the objective knowledge test in Part B.

Part B. For the knowledge of symbols and terms the score is calculated as the sum of correct answers, leading to a maximum score of 21+5=26. This objective score will henceforth be called the CLS-score. The assumption that it predicts user's performance with interactive technology better than the subjective computer experience assessed in part A will be tested.

3 Scale development

3.1 Method

3.1.1 Procedure

Collecting items. The items for part A (experience with computers) are largely based on existing questionnaires such as the INCOBI (Richter et al., 2001) and were selected to assess the scope of main applications for computers. Response alternatives for diversity of computer tasks were presented in a four point Likert scale containing never, seldom, sometimes and often as possible answers. The answer "unknown" was added for respondents who do not know the terms used for the computer tasks.

The items for part B (computer literacy) were selected as prototypical symbols (45) and terms (15) from computers and other widespread electronic devices like copy machines and CD-players. It was our goal to find an abstract representation of common symbols rather than a high fidelity copy from an existing device, so the items would be largely independent of specific products, operating systems and applications.

The symbols were ordered in 6 categories (devices in general, desktop, browser, cursor shapes, keyboard, widgets) and built right into the questionnaire using MS-Word (2007). The terms were selected from dictionaries (e.g. www.langenscheidt.de) and encyclopedias (e.g.

Gookin & Gookin, 1998; www.wikipedia.org) and amended with our own wording. Response alternatives were presented in a matching task, which is well suited for knowledge tests and requires little paper space. One distractor per category was added to further reduce guessing chance (Lienert & Raatz, 1998; Bortz & Döring, 2006). The items were checked for accuracy, comprehensibility and relevance by experts and the emerging preliminary CLS was tested with ten non-experts who were asked for critical feedback.

3.1.2 Participants

The resulting first version of the CLS contained 60 items (45 symbols +15 terms) and was tested with an incidental sample of n=120 adults aged 21-75 years (*Median*=35 years, M=40.53 years, SD=15.69). 68% were younger than 50 years and shall henceforth be called the "young group", while the others form the "old group". Gender was evenly distributed (54% female, 46% male). Most of the participants used computers for text editing (82%), surfing the web and email (78%), and the least used it for programming (9%). Of the 14% who had never used a computer, 94% were in the old group (n=116).

3.2 Results

The quality of the computer literacy scale (part B) was assessed through the indices of internal consistency (Cronbach's alpha), discrimination power and item difficulty. Internal consistency was α=0.96, indicating a high homogeneity, while discrimination power ranged from r=0.22 to r=0.84. Item difficulty was low for the young group, but reasonably broad for the old group, ranging from P=0.13 to 0.87. Accordingly, a Kolmogorov-Smirnov-Test revealed, that the CLS scores of part B were normally distributed for the old group ($D(39) = 0.10$; $p > .10$) but not for the young group ($D(81) = 0.12$; $p < .01$).

3.2.1 Item selection

The item selection based on item difficulty and discrimination power yielded a revised version of the CLS that met our goal of economical assessment: the 60 items were reduced to 30 and symbol categories were merged from 6 into 3 sets, while terms were reduced to one set of items. The revised version was supposed to be well suited for older adults and people with little computer literacy. It is described in detail on page 6 and was used in further studies with one exception in part A: The diversity score was calculated slightly different from the current version of the CLS, as it contained surfing & emailing as computer tasks but no further Internet tasks, resulting in a maximum score of 8x3=24 points.

3.2.2 Relationship of computer literacy and computer experience

To gain some insight on the relationship between computer literacy and the duration, intensity and diversity of computer experience, a multiple correlation was conducted. However, since predictors and criteria were not normally distributed, its prerequisites were violated (Field, 2005) and the data could merely provide some indication, that diversity (r=.59; p<.01; β=.63) and intensity (r=.22; p<.05; β=.17) of computer use were positively correlated with computer literacy (N=114; R^2=.541), while the duration was not (r=.05; p>.05; β=.04). The last result seems quite plausible, since a 15 year old cannot have 20 years of computer experience, even if she has more computer literacy than a 50 year old. Yet the assumption that the duration is a weak measure and tells us little about the actual competence of the person, while diversity seems to be quite a good predictor of computer literacy, better still than intensity, needed to be addressed in further studies.

4 Scale validation

Scale validation is described in two parts. In the first, the relationship between the CLS-score and performance using a simple interactive computer system (a ticket vending machine) was investigated (criterion validity). In the second, the relationship between the CLS and a measure of computer expertise was measured (convergent validity, Lienert & Raatz, 1998).

4.1 Method

CLS and Test performance. To investigate the relationship between the CLS-score and performance using a simple interactive computer system, a simulated ticket vending machine (TVM) of the BVG (Berlin Public Transportation) was built in Squeak/Smalltalk (see Black et al (2007) for an introduction) and presented on a 19” touch screen monitor. The symbols and terms used in the GUI of the simulation were not used as items in the CLS. Figure 2 shows a screenshot of the simulation.

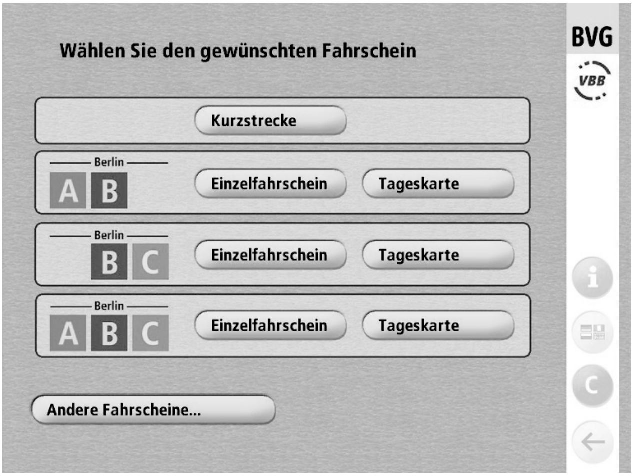

Figure 2: Screenshot of the simulated TVM

4.1.1 Procedure

In seven tasks, participants had to select tickets for purchase using this simulation. Effectiveness was measured as selecting the correct ticket, leading to a maximum score of 100%=7 task points. Before and after using the simulation, participants filled out the CLS and other questionnaires and were interviewed by the investigator, who was present for the whole duration of 60-90 min. See Sengpiel et al (2008) for a detailed description.

4.1.2 Participants

A total of *n*=17 older adults (M=67.2 years, SD=2.6, 8 female, 9 male) and *n*=17 younger adults (M=25.4 years, SD=2.1, 10 female, 7 male) participated. Both age groups were relatively highly educated (21 College (Fach-/Hochschule), 8 Highschool (Abitur)) and most used the TVM once a month or less (28). People in the younger group were mostly students (9) or working (7), while the older group consisted mainly of pensioners (16).

4.2 Results

First, descriptive statistics of CLS scores for the two age groups are provided, then the relation between CLS-Scores and TVM performance is described. Finally follows a brief item analysis.

4.2.1 CLS Scores

Regarding computer literacy, older adults reached *M*=14.4 points (SD=7.06, Min=3, Max=25) on the computer literacy scale, while younger adults reached *M*=23.9 points (SD=2.28, Min=19, Max=26). This difference is significant t(19.29) = -5.33, p < .001, and represents a strong effect r= .77. The CLS scores were normally distributed in the older sample (D(17)=0.168, n.s.), but not in the younger sample (D(17)=0.267, p<.01).

Regarding the ratings of computer experience, older adults reported a duration of *M*=6.94 years (SE=1.83, Min=0, Max=20) of using computers and an intensity of *M*=2.88 hours per week (SE=0.92, Min=0, Max= 14) of using computers. Younger adults reported to have used computers for *M*=10.47 years (SE=0.79, Min=3, Max=17), which was not significantly longer than the older group, and to spend *M*=26.85 (SE=3.27, Min=6, Max=50) hours per week using computers. This difference to the older group was significant (t(18.49) = -7.06, p<.01, r= 0,85) and represents a strong effect (Field, 2005).

For diversity of computer use, the older group scored *M*=4.14 points (SE=1.29, Min=0, Max=15) while the younger group scored *M*=14.69 points (SE=0.94, Min=7, Max=21). The difference to the older group was significant with t(28) = -6.70, p<.01, r= 0,78) and represents a strong effect.

4.2.2 CLS and task-performance

Older adults differed from young adults in task effectiveness: On average, young participants (M= 0.86, SE=0.04) were able to select the correct ticket more often than old participants (M=0.70, SE=0.05). This difference is significant (t(32)=-2.43, p<.05). Figure 3 shows the age differences in participants' effectiveness, computer literacy and computer experience.

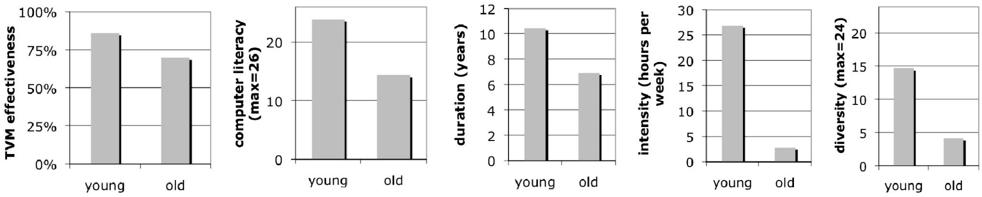

Figure 3: Age differences in TVM effectiveness, computer literacy and computer experience (duration, intensity, diversity)

Correlational analysis was conducted to investigate the relationship between CLS-Scores and TVM performance, separately for both age groups. In the older group, performance and computer literacy were highly correlated ($\tau = 0.52$, $p < 0.01$), as were performance and diversity ($\tau = 0.45$, $p<0.05$). Performance and duration ($\tau = 0.32$, n.s.) and intensity ($\tau = 0.30$, n.s.) were not significantly correlated. Computer literacy and computer experience were highly correlated as well: duration ($\tau = 0.47$, $p<0.05$), intensity ($\tau = 0.51$, $p<0.05$), diversity ($\tau = 0.53$, $p<0.05$).

In order to assess the unique contribution of computer literacy and computer experience on TVM-performance, a partial correlation analysis was conducted. The best predictor of performance was computer literacy ($R^2=0.37$), followed by diversity of computer experience ($R^2=0.25$). When computer experience (diversity, years and hours per week) was controlled for, computer literacy still explained much of the variance in TVM-performance ($R^2=0.17$), while computer experience (diversity) explained only very little variance ($R^2=0.02$), when computer literacy was controlled for. In the younger group, neither computer literacy nor computer experience (diversity) were significant predictors of TVM-performance. The only significant correlation was between performance and duration ($\tau = 0.42$, $p<0.05$).

It can be concluded, that, for the older group, computer literacy measured as knowledge of symbols and terms was a valuable predictor of TVM performance, more so than the more common subjective self report scales of computer experience.

4.2.3 Item analysis

The quality of the computer literacy scale was assessed through the indices of internal consistency (Cronbach's alpha), discrimination power and item difficulty.

Internal consistency of the scale was high ($\alpha=.94$) and the items' discrimination power ranged from $r=0.28$ to $r=0.89$, while item difficulty was low for the young group ($M=0.92$, $SD=0.12$), but reasonably broad for the old group ($M=0.55$, $SD=0.19$) ranging from $P=0.06$ to 0.94 (see Figure 4). Accordingly, a Kolmogorov-Smirnov-Test revealed, that the CLS scores of part B were normally distributed for the old group ($D(17) = 0.17$; $p >.10$) but not for the young group ($D(17) = 0.27$; $p < .01$).

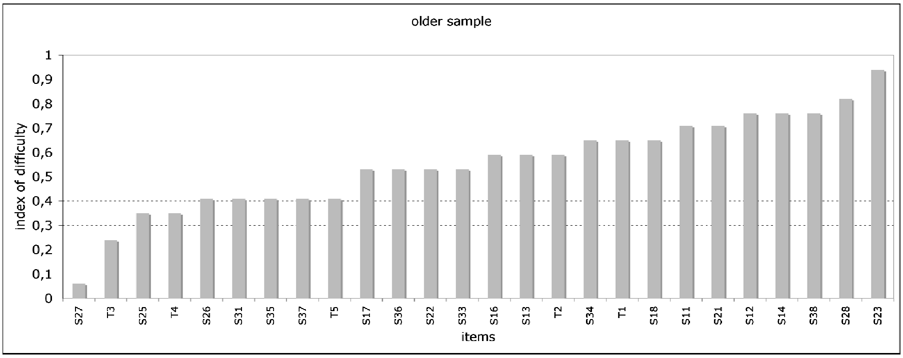

Figure 4: Indices of item difficulty for the older sample

4.3 Computer literacy and computer expertise

As a measure of convergent validity, the relationship of the CLS and a computer expertise questionnaire was investigated. Participants took part in a study conducted and described in detail by Schneider et al (2008). They filled out the CLS and the computer expertise questionnaire for older adults (CE) of Arning & Ziefle (2008). The CE contains 18 items, which assess theoretical (nine items) and practical (nine items) computer knowledge by describing typical tasks or problems that occur using computers and asking participants to mark the optimal course of action in a multiple choice task with 4 alternatives (Arning & Ziefle, 2008). A total of n=90 adults (M=47.5 years, SD=16.8, 36 female, 54 male) participated. They were relatively highly educated: 40 had finished College (Fach-/Hochschule), 15 were still in college and 27 had some professional training (abgeschlossene Ausbildung) and most used a computer privately or at work. Results show that CLS and CE were moderately correlated (τ=.62, p<.01), which indicates that they measure related constructs, even though they do so in very different ways.

5 Discussion

The lack of age specific instruments for the economical assessment of computer literacy has led to the development of the CLS. The distribution of test scores shows that its difficulty level is well suited for older adults, but too easy for younger and more computer literate people. For older adults, the CLS predicted performance of interaction with a simulated ticket vending machine better than any subjective measure of computer experience. Fitting on one sheet of paper and having a completion time of 10-20 min it proved to be an economical, age specific, reliable and valid instrument for the assessment of basic computer literacy in older adults.

Practical Implications. With a growing research interest in older adults and a growing number of researchers using computers with GUI to assess their performance, it becomes increasingly important to have economical and age-specific instruments to measure their computer literacy as control variable. The CLS provides such an instrument and is available as paper and online version (www.computer-literacy.net).

Limitations and further research. As of now, the CLS tests only declarative knowledge of symbols and terms, while the procedural knowledge of interaction patterns may have an equally important influence on participants' performance. To address this issue, an extension of the CLS with interactive components is currently developed. This extension will also include more difficult items to broaden its range of application to younger and more computer literate people.

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