Computer attitudes, cognitive abilities, and technology usage among older Japanese adults

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H. Umemuro, Computer attitudes, cognitive abilities, and technology usage among older Japanese adults. Gerontechnology 2004; 3(2): 64-76. *This study investigates the relationships among computer attitudes, cognitive abilities, and the usage of various technologies among older Japanese adults.* ***Methods.*** *Fifty Japanese adults, 32 males and 18 females, aged 60 to 80, participated. Participants' experience of usage and possession of 18 products and services that utilize various technologies were investigated by questionnaire. The Attitudes Toward Computers Questionnaire (ATCQ) was employed to assess the computer attitudes of the participants. Spatial visualization, spatial orientation, associative memory, perceptual speed, and field independence were measured using the Kit for Factor-Referenced Cognitive Tests.* ***Results*** *showed a variation in the percentages of participants who had used the assessed products and services (usage ratio) from 8% to 94%. Gender difference could be seen only in the Control subscale of the ATCQ scores, while a significant gender difference could be seen in all cognitive ability factors examined except for associative memory. More positive computer attitudes, especially regarding Comfort and Interest, were related not only to greater usage of computers but also to the greater usage of a number of computerized products and services. Some of the computer attitude subscales were also found to be related to the usage of products and services whose usage ratios were relatively low. On the other hand, higher cognitive abilities, especially spatial abilities and field independence, were related to the use of products and services whose usage ratio were relatively high.* ***Discussion.*** *The implications of the results include the possibilities of mutual relationships among computer attitudes, cognitive abilities, and technology usage among older adults, utilization of one of these factors as a predictor for others, as well as for the design of interventions and training strategies.*

Keywords: cognitive ability, cognitive style, field dependence, computer attitude

Among the world's developed countries, Japan has one of the most rapidly aging populations as the number and percentage of the elderly has been increasing for decades. The proportion of the population aged 65 and over, which was 17.4% in 2000[1], is estimated to reach 35% in 2050[2]. On the other hand, new technologies have been rapidly introduced into daily lives of the general population as well as into workplaces; potentially, older adults are among those who can benefit most from utilizing them[3]. A wide variety of assistive technologies are in place for people whose physical or cognitive functions are declining. Information and communication technologies should be able to support older people in their independence, socialization, health promotion, and for the provision of caregiving services, especially in cases of mobility constraints. Therefore supporting the elderly in making use of new technologies has become increasingly important.

Meanwhile, to what extent older people are actually using technologies shows great diversity among individuals. In 2001, while 44.0% of the Japanese population utilized the Internet, the fraction remained at 15.9% for adults in their sixties[4]. This implies that while some older adults might be using computers as much as younger generations do, many others might be reluctant to adopt them. Understanding the factors contributing to these individual differences in technology usage should have implications for the design of products and training for older adults, which could well incorporate the individuals' characteristics. Such interventions are expected to support broader utilization of technologies among the elderly, as well as among their younger counterparts.

One factor likely to influence the use of technology is people's attitude towards it. Computer attitude[5] and computer anxiety[6] have been studied in relation to computer usage. Ellis and Allaire[7] showed that computer anxiety is a major factor influencing older users' intent to use computers. Umemuro and Shirokane[8] demonstrated a positive attitude, especially the factor representing users' liking of computers, was a reliable predictor of actual computer usage in the long term. However, relationships between attitudes and usage of technologies other than computers have seldom been studied. One of the reasons is the difficulty of constructing attitude measurement tools for general technologies. Efforts to establish such a general attitude score by Frantom, Green, and Hoffman[9] reported difficulties in including a wide variety of technologies in a limited number of questionnaire items. In their questionnaire the word 'technology', instead of specific product categories, was used to refer to a broad range of technologies, which might bring ambiguity into subjects' understanding of the target technology. They also argued the necessity of including a larger number of alternatives to target technologies in order to assess subjects' preferences between them, which might also be difficult with a limited number of questionnaire items. Therefore, if well-established measurements to assess attitude toward one technology, namely computers, can also be used to predict the usage of other technologies, these would be convenient tools to assess individual differences in technology usage.

It has been a general belief that older adults have more negative attitudes toward technology such as computers than their younger counterpart. Based on a survey study in the 1980s, Brickfield[10] reported that older adults were more negative towards technologies and less willing to use them. However, recent research has failed to ascertain any significant difference between older and younger participants[11-16]. The work of Dyck and Smither[17] suggested an age difference such that older participants had more positive attitudes toward computers than the younger participants, as well as a lower confidence about their ability to use computers. Czaja and Sharit[18] employed the Attitude Towards Computer Questionnaire[19], a seven-dimensional computer attitude scale, and reported that although there was no age difference in overall attitude, there were age effects for four (Comfort, Efficacy, Dehumanization, and Control) of seven subscales. These results imply the necessity of using a multidimensional computer attitude scale for the assessment of older adults' attitude towards technology.

Other possible factors that are thought to influence technology usage are cognitive abilities. Among cognitive abilities that have been studied, spatial ability has been reported to relate to the usage and learning of computer skills[20-23]. Cognitive styles, such as field independence, were also

studied in relation to the performance of hypermedia usage[24,25]. In addition to these two factors, perceptual speed is also considered to be important for usage of technologies including computers[20], because some new technologies such as computers often present large amounts of information to users and also require visuomotor control in their operation. However, visual perception[26] and motor control[27] also decline with aging. Memory is also expected to influence an older adults' use of technologies, while declines of memory functions with aging are also observed[28,29]. Among a number of memory functions, this study focuses on associative memory. Associative memory is the function that associates specific input representations to specific output representations such that when one is encountered, the other can be recalled. This memory function is considered to play an important role in remembering interface presentations and user goals in association with operation procedures. Thus associative memory is expected to determine learning performance significantly.

The purpose of this study is to investigate the relationships among computer attitude, cognitive abilities, and the usage of a wide variety of technologies, aiming to clarify the factors that influence older adults' technology usage. These relations are investigated and compared across the technologies to find the differences in what factors are relevant to what technologies. This study focuses on a detailed investigation of individuals' attitudes and cognitive abilities in relation to their use of technologies, rather than the general tendency of technology usage among an older population.

METHODS

Participants

Fifty Japanese adults aged between 60 and 80 yrs (M = 66.8, SD = 4.8) participated voluntarily in this study. Of these, 32 were male (age: M = 66.7, SD = 4.8) and 18 female (age: M = 66.9, SD = 5.0). Participants applied to participate in this study in response to advertisements on regional newspapers. All participants resided in suburban Tokyo.

Procedure

The investigation was conducted between October 2002 and April 2003. Participants gathered in groups, which consisted of seven to ten people at one time, at local sites. They had the purpose and outline of the research explained, and it was confirmed to them that they reserved the right to decline to offer personal information and/or terminate their participation at any time during the investigation. Participants were then asked to complete the survey questionnaire, which was in three parts. Part 1 sought participants' demographic data and health condition. Part 2 asked about usage experience and possession of various products and services using modern technologies. Part 3 assessed participants' computer attitudes. Following a 10 min. intermission, each participant received a battery of cognitive ability tests. There were five tests corresponding to five cognitive abilities. All participants in a group took the test simultaneously, conducted by the investigator. With a 5 min. intermission in the middle, the testing took about 90 min. to complete.

Measurements

The questionnaire and test batteries used in this study were adapted from those developed by the Center for Research and Education on Aging and Technology Enhancement (CREATE)[30]. The original battery of questionnaires and tests was developed for the Center's primary activity aiming to develop a comprehensive database on aging and technology that would consist of information regarding user preference and needs, problems with existing systems, and efficiency of design

solutions. The original set was designed to probe various information including older adults' demographics, health status, cognitive and physical abilities, and attitudes and anxiety towards computers. Conducting whole sessions of the original set required multiple days of on-site assessments plus an extra home assessment. For the present study only relevant sections were selected and put together so that the assessment could be conducted within a few hours. Some questionnaire items and test items were modified or appended according to the purpose of this study and the social circumstances existent in Japan. Participants' background information such as occupational status and education were not included because this study focused on the relationship between cognitive abilities, attitudes, and technology usage.

Technology usage was assessed by a questionnaire asking participants their experiences and possession of 18 products and services based on modern technologies. These were: answering machine, touchscreen type automatic teller machine (ATM), car cruise control, car navigation system, CD player, cellular phone, computer, computerized catalog in a library, copier, e-mail, facsimile (fax), home security system, microwave oven, self-service gas station, video camera, video game, video player/recorder (VCR), and the World Wide Web (WWW).

Participants' computer attitudes were investigated using the Attitudes Toward Computers Questionnaire (ATCQ)[19], a 35-item multidimensional scale for assessing seven dimensions of attitude toward computers that has been used in some recent studies[8,18,20]. Seven subscales corresponding to the attitude dimensions were: feelings of comfort with the computer and its use ('Comfort'), feelings of competence with the computer ('Efficacy'), the belief that computers are important to both men and women ('Gender Equality'), the belief that people control computers ('Control'), the belief that computers are dehumanizing ('Dehumanization'), the extent to which participants are interested in learning about and using computers ('Interest'), and the belief that computers are useful ('Utility').

Participants responded to each item by a five point Likert scale between 1 (strongly agree) and 5 (strongly disagree). Responses were converted, so that larger numbers represent more positive attitudes, and summed to obtain scores for each subscale. Each subscale consists of five (Comfort, Efficacy, Gender Equality, Control, and Interest) or six (Dehumanization and Utility) items; that is, one item in each of Dehumanization and Utility also belongs to one of the subscales. Thus subscale scores ranged between 5 and 25, or 6 and 30, respectively.

Participants' cognitive abilities were assessed using the Kit of Factor-Referenced Cognitive Tests developed by Educational Testing Service[31]. As noted above, five tests corresponding to five cognitive abilities were selected and applied: two spatial abilities: visualization (VZ2) and orientation (S2), associative memory (MA1), perceptual speed (P2), and field independence (CF1). To allow comparisons with previous studies reporting scores for the same cognitive tests, the scores were used for further analysis without conversion.

RESULTS

Technology use

Table 1 summarizes the percentages of participants who reported experiences with or possession of the products and services. This study was not aiming to investigate the penetration of technologies in general, thus the results in Table 1 may

Table 1: Percentages of participants who reported any experience and/or possession of technology products / services (N = 50). Products and services are listed in descending order of overall experience ratios. Asterisk indicates significance levels of chi-square tests between gender groups (α=0.05)

Product / service	Experience (%)			Possession (%)		
	Total (n=50)	Male (n=32)	Female (n=18)	Total (n=50)	Male (n=32)	Female (n=18)
Microwave oven	94	94	94	98	97	100
Automatic teller machine (ATM)	94	91	100	-	-	-
Copier	92	100	78	48	56	33
Facsimile	90	100	72	76	88	56
Answering machine	88	91	83	82	81	83
Video player/recorder (VCR)	78	94	50	76	84	61
Computer	78	88	61	66	78	44
CD player	68	69	67	70	66	78
World Wide Web (WWW)	66	78	44	-	-	-
Cellular phone	62	72	44	52	56	44
E-mail	54	66	33	-	-	-
Computerized library catalogue	30	41	11	-	-	-
Video camera	26	38	6*	14	19	6
Video game	26	31	17	22	25	17
Car navigation system	16	25	0	12	19	0
Car cruise control	14	19	6	12	16	6
Self-operated gas station	14	22	0	-	-	-
Home security system	8	6	11	8	6	11

not be representative of the technology usage by the general population of older Japanese adults. Indeed, the relatively high experience ratios suggested that the subject sample represented a population who were relatively adaptive to technologies. Nonetheless, Table 1 suggests the existence of a variation in utilization across participants and also across the kinds of products/services.

A series of chi-square tests were conducted to investigate gender differences in technology usage. Significant gender difference was only found in video camera use, for which more male participants reported experience than female. Only male participants reported usage experiences for the car navigation system and a self-operated gas station, although statistically not significant (chi^2 (df = 1) = 3.658 and 2.942, respectively). However, as mentioned above, these existence and lack of gender difference might due to the specific sample employed in this study, and might not be representative for wider categories of Japanese older population.

For each of the products/services, participants were divided into two groups: a group of participants who had experiences with the product/service ('use' group) and a group of participants who had no experience with it ('non-use' group). There were two reasons that experience was used as the usage index. First, possession may have a higher threshold than experience; it might be easier to try somebody else's product, while buying might be a more complex decision influenced by many factors, including economic status. Second, the possession in households may not necessarily be representative of actual usage, as seen in female participants' experiences and the realities of the

possession of microwave ovens and VCRs. Therefore, experience was considered to be a better index representing participants' willingness to try new technologies. The percentage of the participants who had experienced a product/service will be further referred to as the product's 'usage ratio'. Then attitudes and cognitive abilities were compared between these two usage groups for each product/service.

There were three products and services whose usage ratios were higher than 90%, and one product whose usage ratio was lower than 10%. Comparisons between usage groups for these products/services may be less informative, because of small numbers in one of the usage group pairs. Careful interpretations and discussions are needed for the comparison results of these products and services. The issue will be further discussed in the Discussion section.

Table 2: Means and standard deviations (in parentheses) of Attitudes Toward Computers Questionnaire (ATCQ) subscale scores. (N = 50). Asterisk indicates significance in the t test between two gender groups (α=0.01)

Subscales	Total	Male (n=32)	Female (n=18)
Comfort	17.1 (3.4)	17.6 (3.6)	16.1 (2.7)
Efficacy	17.2 (2.4)	17.5 (2.6)	16.7 (2.1)
Gender Equality	15.9 (2.8)	16.0 (3.1)	15.6 (2.0)
Control	18.7 (2.3)	19.4 (1.9)	17.5 (2.4)*
Dehumanization	21.1 (3.4)	21.5 (3.7)	20.6 (2.8)
Interest	19.2 (2.9)	19.4 (3.0)	18.8 (2.8)
Utility	20.5 (3.9)	21.1 (3.9)	19.2 (3.5)

Computer attitudes and usage

Table 2 summarizes ATCQ subscale scores of all participants and by gender groups. A series of *t* tests revealed that a significant gender difference could be seen only in the Control subscale, where males showed more positive attitudes. Again, the existence or lack of gender difference might be due to the specific sample employed in this study, and might not be representative for wider categories of the Japanese older population.

ATCQ subscale scores were then compared between usage groups for each product/service. Table 3 summarizes the results of the comparisons. A series of *t*-tests revealed that the use group for computers showed significantly higher scores in Comfort, Dehumanization, Interest, and Utility subscales than the non-use group. All these subscales indicated more positive attitudes for users, which is in line with previous studies reporting the relation between computer usage and positive attitudes including Liking or Interest. In addition, the use groups of two services that directly utilize computers, namely the WWW and e-mail, also showed higher scores in these subscales.

For a number of other computerized products, the same tendency that positive attitudes were associated with usage could also be seen. The use group of ATMs was significantly higher in Comfort subscale, and moderately higher in Efficacy and Gender Equality subscales. The use group of facsimiles was significantly higher in Comfort and Utility subscales. Cellular phone users were significantly higher in Comfort subscale and moderately higher in Interest. Computerized library catalog users were only moderately higher in Comfort and Dehumanization subscales. Car navigation users were significantly higher in Gender Equality and Utility subscales, and moderately higher in Comfort, Dehumanization, and Interest subscales. Finally, the use group of self-operated gas stations showed significantly higher scores in Comfort and Utility, and moderately higher scores in Gender Equality, Dehumanization, and Interest subscales.
It is also noteworthy that all four products and services whose usage ratios were less than 20% showed significant differences

*Table 3: Means and standard deviations (in parentheses) of Attitudes Toward Computers Questionnaire (ATCQ) subscale scores by usage groups of products / services (N = 50). Symbols indicate significance levels of t tests between usage groups: ** p < .01; * p < .05; + p <*

Products / Services		Comfort	Efficacy	Gender Equality	Control	Dehumanization	Interest	Utility
Microwave oven	Use	17.2 (3.4)	17.3(2.5)	16.0 (2.8)	18.7 (2.3)	21.3 (3.4)	19.3 (2.9)	20.6 (3.9)
	Non-use	14.7 (2.5)	16.0 (1.0)	15.0 (1.0)	18.0 (1.0)	18.7(2.3)	17.0 (3.0)	18.3 (2.5)
ATM	Use	17.4 (3.1)*	17.4 (2.3)+	16.1 (2.6)+	18.7 (2.3)	21.3 (3.4	19.3 (2.9)	20.6 (3.9)
	Non-use	12.7 (4.9)	14.7 (3.2)	13.0 (3.5)	19.0 (1.0)	18.3 (2.5)	16.7 (1.5)	17.7 (2.3)
Copier	Use	17.2 (3.4)	17.3 (2.3)	15.9 (2.8)	18.8 (2.2)	21.2 (3.5)	19.2 (3.0)	20.5 (4.0)
	Non-use	15.3 (2.9)	16.5 (3.7)	16.3 (2.5)	17.3 (2.5)	20.8 (0.5)	19.3 (2.2)	19.8 (1.7)
Facsimile	Use	17.3 (3.5)**	17.2 (2.5)	15.8 (2.8)	18.8 (2.3)	21.2 (3.5)	19.2 (3.0)	20.7 (4.0)**
	Non-use	15.4 (0.5)	17.2 (1.9)	16.6 (2.9)	17.4 (1.8)	20.2 (2.5)	19.0 (1.2)	18.4 (1.1)
Answering machine	Use	17.2 (3.3)	17.2 (2.5)	15.6 (2.5)*	18.6 (2.0)	21.2 (3.4)	19.2 (2.5)	20.4 (3.7)
	Non-use	16.3 (4.5)	17.5 (1.9)	18.0 (4.0)	19.7 (3.7)	20.5 (3.6)	19.2 (5.5)	20.7 (5.4)
Video player/recorder	Use	17.3 (3.5)	17.3 (2.6)	16.2 (2.9)	19.2 (2.0)**	21.6 (3.5)+	19.4 (2.9)	21.0 (3.7)*
	Non-use	16.1 (2.8)	17.0 (1.8)	14.9 (1.9)	17.0 (2.4)	19.6 (2.3)	18.6 (3.0)	18.5 (4.0)
Computer	Use	17.9 (3.1)**	17.5 (2.3)+	16.1 (2.7)	18.7 (2.3)	21.7 (3.4)*	19.6 (3.0)*	21.3 (3.8)**
	Non-use	14.1 (2.7)	16.2 (2.6)	15.0 (3.1)	18.6 (2.1)	19.1 (2.5)	17.6 (1.7)	17.5 (2.2)
CD player	Use	17.7 (2.6)+	17.6 (2.0)	16.2 (2.9)	18.5 (2.2)	21.7 (3.2)+	19.7 (2.2)	21.1 (3.7)+
	Non-use	15.6 (4.5)	16.6 (3.0)	15.3 (2.3)	19.1 (2.3)	20.0 (3.5)	18.1 (3.8)	19.0 (3.9)
World Wide Web	Use	18.2 (2.7)**	17.5 (2.2)	16.3 (2.8)	18.7 (2.4)	22.1 (3.1)**	20.0 (2.1)**	21.7 (3.6)**
	Non-use	14.9 (3.7)	16.7 (2.8)	15.0 (2.4)	18.6 (2.0)	19.3 (3.2)	17.5 (3.6)	18.1 (3.4)
Cellular phone	Use	17.9 (3.3)*	17.6 (2.6)	15.6 (2.8)	18.6 (1.9)	21.5 (3.2)	19.7 (2.3)+	20.9 (3.7)
	Non-use	15.7 (3.2)	16.6 (2.0)	16.4 (2.7)	19.0 (2.8)	20.6 (3.8)	18.2 (3.6)	19.7 (4.0)
E-mail	Use	18.4 (2.5)**	17.6 (2.4)	16.4 (3.0)	19.0 (2.2)	22.2 (3.1)*	20.0 (2.2)*	22.2 (3.3)**
	Non-use	15.4 (3.6)	16.8 (2.4)	15.2 (2.3)	18.3 (2.3)	19.9 (3.3)	18.2 (3.3)	18.5 (3.6)
Computerized library catalogue	Use	18.5 (2.5)+	17.6 (1.9)	15.5 (1.2)	19.1 (2.2)	22.4 (3.5)+	20.0 (2.1)	21.4 (3.2)
	Non-use	16.5 (3.6)	17.1 (2.6)	16.1 (3.2)	18.5 (2.3)	20.6 (3.2)	18.8 (3.2)	20.1 (4.1)
Video camera	Use	19.1 (2.4)*	17.9 (2.3)	16.5 (3.1)	19.0 (2.0)	21.5 (2.8)	20.3 (2.5)+	21.9 (3.4)+
	Non-use	16.4 (3.4)	17.0 (2.4)	15.7 (2.6)	18.6 (2.4)	21.0 (3.6)	18.8 (3.0)	19.9 (3.9)
Video game	Use	18.2 (3.2)	17.2 (2.0)	15.9 (1.6)	19.4 (1.7)	20.8 (3.3)	19.9 (2.0)	21.0 (3.6)
	Non-use	16.7 (3.4)	17.3 (2.6)	15.9 (3.1)	18.5 (2.4)	21.2 (3.5)	18.9 (3.1)	20.3 (4.0)
Car navigation system	Use	18.9 (2.2)+	17.8 (2.8)	19.1 (4.5)*	19.3 (2.5)	23.0 (2.7)+	21.0 (2.0)+	23.9 (3.3)**
	Non-use	16.7 (3.5)	17.1 (2.3)	15.3 (1.7)	18.6 (2.2)	20.8 (3.4)	18.8 (2.9)	19.8 (3.6)
Car cruise control	Use	19.0 (2.6)+	18.1 (2.5)	17.9 (3.5)*	18.0 (2.3)	22.1 (2.3)	20.4 (2.4)	22.7 (4.0)+
	Non-use	16.8 (3.4)	17.1 (2.4)	15.6 (2.5)	18.8 (2.3)	21.0 (3.5)	19.0 (3.0)	20.1 (3.7)
Self-operated gas station	Use	19.4 (2.1)*	18.3 (2.6)	18.6 (3.8)+	18.6 (1.9)	23.1 (2.7)+	20.6 (1.9)+	24.0 (3.3)**
	Non-use	16.7 (3.4)	17.1 (2.4)	15.5 (2.3)	18.7 (2.3)	20.8 (3.4)	18.9 (3.0)	19.9 (3.7)
Home security system	Use	19.5 (2.6)	19.3 (3.1)+	14.8 (0.5)*	18.5 (2.6)	22.0 (4.5)	19.8 (3.4)	22.0 (3.4)
	Non-use	16.9 (3.4)	17.1 (2.3)	16.0 (2.9)	18.7 (2.3)	21.1 (3.3)	19.1 (2.9)	20.3 (3.9)

in some of the attitude subscales between use and non-use groups. In addition to the car navigation systems and self-operated gas stations mentioned above, the use group of car cruise control showed significantly higher Gender Equality subscale scores and moderately higher scores in Comfort and Utility. The use group of home security systems also showed the general tendency that users showed more positive attitudes in all but Gender Equality subscales.

Cognitive abilities and usage

As three of the fifty participants did not complete the cognitive ability test battery, their data were excluded from any further analysis. Table 4 summarizes the scores of the cognitive tests employed in this study. In contrast to computer attitudes, significant gender differences could be seen in most of the cognitive abilities examined except for associative memory; male participants showed higher scores in spatial visualization, spatial orientation, and perceptual speed, and showed a more field-independent cognitive style. Cognitive ability test scores were then compared between usage groups of each product or service. Table 5 summarizes the results of the comparisons. Spatial abilities and field independence appeared to be related to the use of computers, the WWW and e-mail, which is in line with previous studies.

*Table 4: Means and standard deviations (in parentheses) of cognitive tests scores (N = 47). Asterisks indicate significance levels of t tests between two gender groups: *** p < .001; ** p < .01*

Subscales	Total	Male (n=31)	Female (n=16)
Spatial visualization	7.5 (3.8)	8.8 (3.4)	5.0 (3.2)**
Spatial orientation	8.0 (9.5)	8.8 (3.4)	0.4 (7.4)***
Associative Memory	14.3 (6.4)	14.2 (6.2)	14.4 (7.0)
Perceptual speed	35.0 (10.4)	37.7 (10.3)	29.6 (8.4)**
Field independence	8.3 (6.3)	10.7 (6.2)	3.7 (3.5)***

The results also showed that higher spatial abilities, associative memory, and field independence were related to most of the products and services whose usage ratios were more than 50%. In addition to computers, the WWW, and e-mail mentioned above, the use group of copiers showed significantly higher scores in spatial visualization, spatial orientation, associative memory, and field independence. Users of facsimiles showed significantly higher score in spatial orientation and field independence, and also moderately higher scores in spatial visualization and associative memory. The use group of answering machines showed significantly higher scores in spatial orientation and moderately higher scores in spatial visualization. VCR users showed moderately higher spatial orientation, and cellular phone users showed moderately higher field independence. However, among the products and services for wich participants reported high usage ratios, the results showed a reversed tendency for microwave ovens and ATMs; the non-use groups of these products showed higher scores in most cognitive abilities, except that microwave oven users showed significantly higher associative memory scores. The possible reason for this result is discussed in the Discussion section.

Finally, it is also noteworthy that among the products whose usage ratios were lower than 50%, the use groups of video games and car navigation systems showed significantly higher scores in spatial visualization. Users of car navigation systems also showed moderately higher scores in spatial orientation. These results are also discussed in the next section.

DISCUSSION

The purpose of this study was to investigate the relationship between computer attitudes, cognitive abilities, and technology usage of older Japanese adults.

*Table 5: Means and standard deviations (in parentheses) of cognitive test scores by usage groups of products / services (N = 47). Symbols indicate significance levels of t tests between usage groups: ** p < .01; * p < .05; + p < .10*

Products / Services		Spatial visualization	Spatial orientation	Associative memory	Perceptual speed	Field independence
Microwave oven	Use	7.4 (3.8)	7.7 (9.6)+	14.5 (6.4)**	34.8 (10.5)	8.1 (6.4)**
	Non-use	9.0 (2.1)	13.5 (2.1)	8.5 (0.7)	40.0 (8.5)	11.9 (0.2)
ATM	Use	7.5 (3.9)	7.8 (9.7)	13.7 (6.2)*	34.4 (9.9)	8.2 (6.5)
	Non-use	7.3 (2.5)	11.0 (6.0)	22.3 (4.7)	44.0 (15.6)	9.3 (3.4)
Copier	Use	7.9 (3.7)*	9.2 (8.8)**	14.8 (6.4)*	35.7 (10.4)	8.8 (6.3)*
	Non-use	3.6 (3.1)	-5.5 (6.1)	8.3 (3.2)	27.5 (7.5)	3.4 (3.4)
Facsimile	Use	7.8 (3.6)+	9.3 (9.0)**	14.8 (6.5)+	35.8 (10.5)	9.1 (6.2)**
	Non-use	4.7 (4.3)	-3.2 (6.1)	10.0 (4.0)	28.4 (7.1)	2.0 (2.9)
Answering machine	Use	7.9 (3.6) +	9.2 (9.4)*	14.5 (6.5)	35.0 (10.7)	8.5 (6.7)
	Non-use	5.1 (4.2)	-0.3 (5.4)	12.5 (6.0)	35.0 (8.6)	6.9 (1.2)
Video player/recorder	Use	7.9 (3.6)	9.2 (9.3) +	14.0 (6.0)	34.3 (9.4)	8.9 (6.6)
	Non-use	6.0 (4.3)	2.8 (9.3)	15.4 (8.2)	38.0 (13.9)	6.0 (4.6)
Computer	Use	7.9 (3.7)	9.3 (9.5)*	14.6 (6.3)	36.3 (10.2) +	9.4 (6.5)**
	Non-use	5.9 (3.7)	2.9 (7.9)	13.2 (6.9)	30.2 (10.0)	4.4 (3.8)
CD player	Use	7.5 (3.9)	8.3 (9.6)	14.2 (6.2)	34.8 (10.0)	8.5 (6.6)
	Non-use	7.6 (3.5)	7.1 (9.7)	14.6 (7.1)	35.3 (11.7)	7.9 (5.8)
World Wide Web	Use	8.2 (3.8)+	9.8 (9.7)+	13.9 (6.0)	35.3 (9.5)	9.3 (6.7)+
	Non-use	6.0 (3.4)	4.1(8.1)	15.0 (7.4)	34.3(12.3)	6.2 (5.0)
Cellular phone	Use	7.9 (3.4)	9.3 (9.1)	14.8 (6.6)	33.9 (10.8)	9.5 (6.9)+
	Non-use	6.9 (4.4)	5.7 (10.0)	13.4 (6.1)	36.8 (9.6)	6.3 (4.6)
E-mail	Use	8.5 (3.7)+	10.2 (10.3)+	14.0 (5.5)	34.9(10.4)	10.6 (6.7)**
	Non-use	6.3 (3.7)	5.1 (7.8)	14.6 (7.5)	35.0 (10.6)	5.5 (4.5)
Computerized library catalogue	Use	8.1(3.6)	11.2 (9.5)	13.6 (5.7)	35.4 (7.5)	9.3 (7.0)
	Non-use	7.3 (3.9)	6.6 (9.3)	14.5 (6.8)	34.8 (11.5)	7.9 (6.0)
Video camera	Use	8.9 (3.7)	9.5 (8.2)	12.2 (3.6)+	29.8 (7.6)*	9.0 (6.9)
	Non-use	7.0 (3.7)	7.4 (10.0)	15.1 (7.1)	36.9 (10.7)	8.0 (6.2)
Video game	Use	9.4 (3.9)*	10.2 (14.1)	15.7 (6.8)	30.3 (9.8)+	9.0 (7.3)
	Non-use	6.9 (3.6)	7.2 (7.5)	13.8 (6.3)	36.6 (10.2)	8.1 (6.0)
Car navigation system	Use	10.0 (1.8)**	11.5 (5.3)+	12.6 (5.3)	33.0 (4.4)	11.4 (6.5)
	Non-use	7.0 (3.9)	7.2 (10.1)	14.6 (6.6)	35.4 (11.2)	7.7 (6.2)
Car cruise control	Use	7.9 (3.3)	9.7 (6.6)	14.0 (5.9)	36.9 (9.9)	9.0 (4.9)
	Non-use	7.4 (3.9)	7.7 (10.0)	14.3 (6.6)	34.7 (10.5)	8.2 (6.6)
Self-operated gas station	Use	7.9 (3.8)	10.0 (5.8)	14.1(5.1)	31.7 (12.0)	9.7 (6.6)
	Non-use	7.4 (3.8)	7.6 (10.0)	14.3 (6.7)	35.6 (10.1)	8.1 (6.3)
Home security system	Use	7.9 (4.5)	9.8 (10.0)	14.0 (6.2)	33.0 (5.3)	10.9 (8.0)
	Non-use	7.5 (3.8)	7.8 (9.6)	14.3 (6.5)	35.2 (10.7)	8.1 (6.2)

As discussed in the introduction, the extent to wich older people are using technologies shows great diversity among individuals. The results showed that both computer attitudes and cognitive abilities of older adults could be related to some extent to the diversity of their usage of technology. However, those two categories of individual characteristics were found to be related in somewhat different ways.

Computer attitudes, such as Comfort and Interest, were found to be related not only to the usage of computers but also to usage of a number of computerized products and services including ATMs and cellular phones, with which users interact through computer-like screens and keys or touchscreens. This result implies that the measurement tools to assess computer attitudes may also be predictors of the usage of various computerized products.

Some of the computer attitude subscales were also found to be related to the usage of products and services whose usage ratios were relatively low (less than 20%); for most of these, the use groups showed significantly higher scores in Comfort, Gender Equality, and Utility attitude subscales than the non-use groups. This result suggests that these attitudes might represent the users' willingness to use the products whose popularization is in an early phase (Figure 1); the intention to try technologies in this popularization phase is expected to be determined by the users' attitudes, rather than abilities. The differences in Comfort and Utility subscales were not significant for a home security system. This is considered to be due to the small sample size (six) of the use group, which might have made the result statistically not significant. In fact, the difference in Gender Equality subscale was significant, and tendencies in Comfort and Utility subscale scores were consistent with the other three products/service. Thus the above discussion is still considered to hold. On the other hand, the results showed that cognitive abilities, especially spatial abilities and field independence, were related to the use of products and services such as copiers, facsimiles, answering machines, computers, the WWW and e-mail, whose usage ratios were more than 50%. This result suggests that these cognitive abilities might represent the usage of products that were well popularized (Figure 1). In other words, they may be related to the reasons of the last group of people who refused such new technologies. However, for the two most popularized products and services, the microwave oven and ATM, these cognitive abilities were not significantly related; or indeed the relations were even reversed so that the use groups showed lower abilities. One possible explanation for these two exceptions is the small numbers of participants in the non-use groups, as mentioned in the Results section; because these products and services have been popularized for almost all of the general population (94% for both), and there were only three participants in the non-use groups, the difference might not be statistically reliable, or these small exceptions might have special characteristics.

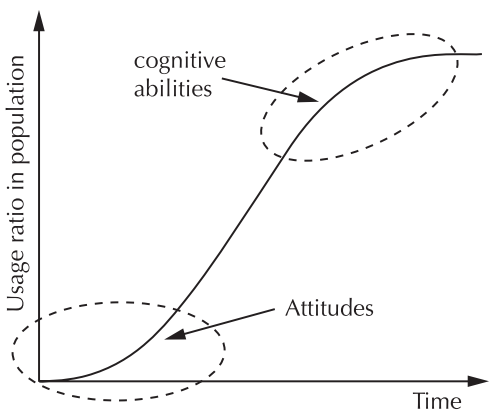

Figure 1. Conceptual model of the popularization of a product and its relation to attitudes and cognitive abilities

Contrarily, among the products whose usage ratios were rather low, the usage of video games and car navigation systems were significantly related to spatial abilities. This result is intuitive because using these products presumably requires user's mental visualization or orientation of the information presented; while using these two products, the products continuously provide users spatial information (virtual or real) through limited channels (displays or voices). In order to utilize this information and further interact with the products, users have to reorganize perceived information and construct its mental representations. That the spatial abilities were also related to the usage of computers and the WWW could be similarly explained.

These relationships discussed above might imply that the computer attitudes and cognitive abilities may be predictors for future technology usage. However, it is also possible that these relationships are rather mutual, such that usage may also change computer attitudes and cognitive abilities. Docampo Rama et al.[32] mentioned the possibility that usage experience with one interface type might "train" certain cognitive abilities that were necessary to use it. Umemuro and Shirokane[8] also discussed the mutual relationship between computer usage and computer attitudes in the long term. The current study does not give any evidence for the existence of causality or mutual relationships; further study is needed to give insights into this issue.

Although the sample size was not large, this study found some significant relationships among computer attitudes, cognitive abilities, and technology usage. A reason for this could be that the sample employed was homogeneous; all participants came from a similar region around Tokyo, and were of a single ethnic group (Japanese). Therefore, to further generalize and confirm the findings of this study, research with a much larger number of participants with a wider variety of characteristics needs to be pursued.

Finally, this study revealed relationships among attitudes, cognitive abilities, and technology use in just a one-time slice. Changes in the usage of technology as well as attitudes and cognitive abilities also need to be studied, because all these individual characteristics presumably change over time, and may relate to each other with time lags. Therefore research into the dynamic changes of the characteristics over a longer time period might reveal causalities or mutual relationships among them as discussed above, and further, the possibilities of how to use one for the prediction of others.

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