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LONG PAPER

Cognitive training via interactive television: drivers, barriers and potential users

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Abstract This paper describes research to investigate the attitudinal and motivational factors that might facilitate or inhibit the uptake and use of cognitive training (CT) applications via interactive television (iTV) by both young and older people and to explore the profiles of potential users of such applications. A questionnaire was designed and distributed as part of the Vital Mind (VM) project. Data from a sample of 848 young and older people were collected and analysed using principal component analysis (PCA) and cluster analysis (CA). PCA of 41 attitude statements identified six components/factors. Three factors measured potential drivers to uptake and use of iTV-based CT applications ('active wellbeing', 'health concern' and 'technophilia') and two measured potential barriers ('unprogressiveness' and 'telly-negativity'). A sixth factor ('active sociability') could act as either a driver or barrier, depending on how socially oriented are different CT applications. CA of the factors and age data revealed seven different profiles of potential users of CT through iTV. Three of the clusters were predominantly older (labelled Cultured-Conservatives, Digital-Immigrants and Telly-Fans), three were younger (labelled Healthy-Strivers, Digital-Natives and Net-Generation) and one was middle-aged (labelled Busy-Interactors). Reported media use and activity (mental, physical and social) were consistent with the attitude profiles of the clusters. The appeal of iTV-based CT was generally high, with Digital-Natives and Digital-Immigrants indicating the most interest. This research provides evidence for the key attitudinal dimensions predictive of likely adoption and use of iTV-based CT, and a refined understanding of target younger and older user markets.

Keywords Interactive television · Cognitive training · Wellbeing service · Older people · Drivers and barriers

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1 Introduction

1.1 Benefits of computerised cognitive training

There is considerable evidence that normal ageing is associated with some changes in intellectual functioning. Whilst the so-called crystallised intellectual abilities (e.g., vocabulary and general knowledge) are maintained and generally increased throughout the life span, there is a significant decline in fluid intelligence abilities, which reflect the manipulation or 'processing' of information (e.g., problem solving, inductive reasoning) [24]. However, investigations into the lifestyle of people who maintain their cognitive vitality well into advanced age found that engaging in hobbies, such as playing chess or crossword puzzles, reading books and generally leading a life of active mental involvement, are some of the key factors that may reduce the effects of age-related cognitive decline [3, 27]. The beneficial effects of mentally stimulating

activities derive from the development of cognitive reserve, which is related to the total cognitive resources available to the individual [53]. Regularly challenging the brain with novel and complex activities stimulates the development of new healthy brain cells and new brain connection as well as protects against neuronal degeneration, which in turn protect against Alzheimer's and other forms of dementia [57].

A growing body of evidence has demonstrated that training and practice of fluid intelligence abilities can lead to significant improvements and have beneficial effects on the cognitive functioning of older adults, even in advanced old age. The most extensive study in this field was conducted by the advanced cognitive training for independent and vital elderly (ACTIVE) group [4], which randomly assigned 2,802 participants aged 65 years and older to one of three cognitive training (CT) interventions (memory training, reasoning training or speed of processing training) or a no-contact control group. Results of this study showed that, compared to the control group, each of the three cognitive interventions significantly improved the cognitive ability it targeted within 5 weeks from the beginning of the interventions, and that these improvements were maintained through the 2 years of follow-up.

In recent years, computerised CT or brain programs such as Lumosity,[1] Posit Science[2] and Mindfit[3] have become enormously popular. Such programs consist of structured sets of brain exercises designed to strengthen specific core cognitive skills, such as attention, memory, perception and problem solving, and are usually available on CD or accessible through the internet via download or browsing.

A promising aspect of CT programs is the potential to delay the onset of age-related cognitive impairment or dementia or even improve cognitive abilities. CT programs can appeal to every age, and in particular to older people who may be experiencing age-related decline in cognitive functions such as perception, attention, memory and speed of processing [10, 21, 25, 40, 51, 64, 65]. Compared to non-computerised interventions designed to stimulate people's minds (e.g., crossword, Sudoku), most computerised CT programs can provide an initial baseline assessment of the key cognitive abilities in order to establish a personalised training program designed specifically for each user. Such programs can automatically record measures of cognitive functions such as memory, reaction time and other skills and, based on their performance, provide users with constant feedback on their cognitive strengths and weaknesses.

[1] http://www.lumosity.com/.

[2] http://www.positscience.com/.

[3] http://www.cognifit.com/.

Investigating the effects of a 14-week computer-assisted CT on different cognitive functions in older people, Günther et al. [20] found that the program led to significant improvements in the participants' working memory, processing speed, learning skills and interference tendency. Some of these improvements were maintained 5 months after training was completed.

A study published in Nature cast doubts on the effectiveness of CT programs on cognitive functioning [49]. Findings from this study suggested that playing with brain-training games will improve the user's performance on those games, but will not transfer to other aspects of brain function. However, this study had several limitations [30, 66]. For example, it did not include adults over 60 years in whom cognitive ability is more variable, and the duration of the training program was very short (a minimum of 10 min a day, three times a week, over a 6-week period).

A recent, more stringent, large-scale randomised controlled study conducted by Smith et al. [55] is more relevant to the research described in this paper. They found that using a CT program for a total of 40 h (1 h per day, 5 days per week, for 8 weeks), which was designed to improve the speed and accuracy of auditory information processing, can drive benefits that generalise to untrained measures of memory and attention in healthy adults over the age of 65 years. Additionally, in a review of studies exploring the impact of speed of processing training programs on cognitive and everyday abilities of older adults, Ball, Edwards and Ross [5] found that this specific training produces improvements across all subtests of the Useful Field of View test (UFOV, a test of visual attention critical for driving performance). These improvements were maintained for at least 2 years, which translated to improvements in everyday abilities and safer driving performance. These studies, along with other studies in the literature [6, 9, 22], support the effectiveness and durability of CT programs in improving targeted abilities in older adults and provide evidence of the impact of such training on untrained cognitive domains.

1.2 Older people's access to cognitive training

As the evidence on the benefits of CT programs increases, it is important to understand how specific target groups, for example older people, are able to access and use these programs.

Older people potentially stand to benefit most from computerised CT, because there is greater variability in cognitive performance among this population [30, 38]. However, they are still less likely than the total population to use a computer and thus to access any computer programs. Recent data from Ofcom [46] show that only 46% of people aged 65–74 years and 28% of people aged 75 and

older own a computer, compared with 84% of 15–24-years-olds. Take-up of the internet is also lower among adults aged 65 years and over (33% vs. 71% of all adults) [47]. Furthermore, of those who have access to the internet at home, older people tend to use it less often and for fewer purposes than their younger counterparts [45].

Studies have identified a number of variables that can significantly influence older people's adoption and use of computers. These include psychological barriers, such as fear [8], lack of confidence and motivation [34], and negative attitudes towards computers [13, 48]. In a study investigating the effects of age, education, computer knowledge and computer anxiety on computer interest in older adults (aged 60–97 years), Ellis and Allaire [16] found that age was negatively associated with computer knowledge and computer interest, and positively associated with computer anxiety. Other studies suggested that some older people are "voluntary non-users", who either have no interest in computers [18] or may think they are irrelevant to their daily lives, offer no advantages and provide no benefits [54].

In contrast to their use of computers and the internet, on average older people (over-65s) spend more than 5 h a day watching television, whereas younger people spend an average of around two and a half hours [45]. Verghese et al. [60] claim that more passive ways of spending leisure time, such as watching TV, tend to be risk factors rather than protective ones for cognitive decline. Verghese et al. demonstrated that increased participation in more active leisure activities (e.g., reading, playing board games, playing musical instruments, and dancing) is associated with a reduced risk of dementia.

1.3 Interactive television as an inclusive medium for delivering cognitive training to older people

With the ongoing switchover from analogue to digital television in the United Kingdom, and in most other European countries, and interactive television (iTV) becoming more and more popular, an increasing number of interactive services (e.g., programme-related content, video on demand, internet access) are offered to TV viewers. This is changing the way people experience television, and transforming them from being simply viewers to interactive users of the television. Interactive TV has the potential to help overcome the digital divide between younger and older generations [19], providing educational, training and wellbeing services to older people who may currently be reluctant or unable to access or use a computer.

Interactive TV-based CT applications are being developed in 'Vital Mind' (VM), a research project funded by the European Union under the Seventh Framework Programme (FP7). This project aims to exploit the increasing adoption of iTV to provide a suite of CT applications designed to engage older adults who are not computer literate. VM applications intend to be easily delivered to the end users' set-top box (STB) over internet protocol (IP), or pre-installed in a Universal Serial Bus (USB) flash drive, which will enable the application to be run on the hosting STB platform without the need for any kind of local installation. This will transform the TV from a broadcast-based medium to an easily available computer-based tool, capable of running local applications independent from the audiovisual TV stream. VM also proposes innovative developments in the detection of hand movements and non-verbal vocal interaction (NVVI, e.g., whistling) in order to enable and facilitate users' accessible and autonomous participation in the CT program. As part of the VM project, key factors useful for the technical design stages of the interactive system and CT program (such as motivations, hurdles and barriers to adoption and use), as well as characteristics of potential target users, have been investigated.

1.4 Previous research on drivers, barriers and potential users of interactive wellbeing services

Expectations of, and attitudes towards, new technology can be meaningful predictors of future use of that technology [11]. The technology acceptance model (TAM) has often been used as a frame of reference in order to understand the potential drivers and barriers of consumer adoption of technology-mediated services [14]. Specifically, TAM uses the "perceived ease of use" and "perceived usefulness" constructs as predictors of users' intentions and actual usage of technology such as information technology and telecommunications. However, although the TAM has made a valuable contribution to predicting adoption behaviours, this model has failed to capture all of the relevant components about the user acceptance of a particular technology and to provide meaningful information due to its generality [35], leading to questions about its validity [36]. Nevertheless, many studies have not used a theoretical framework to identify psychological variables that distinguish users who accept or reject technologies [1, 50].

Traditionally, demographic variables such as gender, age and education have been employed in market segmentation studies to divide the market into segments of users or potential users of specific products or services and to identify the key characteristics of a market segment [29, 62]. However, segmentations based on demographic variables alone are not the most effective in identifying the complete characteristics of a segment, because consumers in the same demographic group may have very different lifestyles [31, 61]. Lin [32] suggested that lifestyle can be defined quantitatively and used as a group identity for

identifying sub-market profiles and targeting customers. Psychographic variables such as lifestyle and attitudes have often been used in market segmentation to gain insights into consumers' behaviour. For example, an attitude-based segmentation has been used by Barnes and colleagues to identify three different profiles of internet users, namely risk-averse doubters, open-minded online shoppers and reserved information-seekers [7]. A similar approach based on category-specific attitudes towards digital and interactive TV, and attitudes to technology and general media consumption, was used by Freeman et al. to examine the digital TV market [17]. By developing an attitude-based consumer segmentation, the authors identified seven types of young and older digital TV consumer, which were strongly differentiated in terms of their adoption of digital TV.

To date little or no research effort has focused on drivers and barriers of CT applications. Nevertheless, previous studies on issues relating to take-up and use of interactive applications and services for health information provide useful insights into the key factors that might facilitate or inhibit their adoption and use. Additionally, some of these studies offer useful descriptions of potential users of such applications and services.

Wilson and Lankton [63] carried out a study to identify which patients would be more likely to use internet-based health services (e-health) and to understand what factors would influence their decisions. They found that service users who were satisfied with their current health care, those who preferred to seek information about their health care, and those who were 'dependent' on the internet (the authors did not explain how they defined internet dependence) for information on health care, government and other institutions were more likely to accept e-health services. The results indicated that though necessary, internet-related knowledge was not sufficient in explaining information-seeking behaviour and suggested that a combination of both knowledge and key cognitive abilities is important for successful information seeking.

Authors from the Oregon Evidence-based Practice Center [28] reviewed the evidence on the drivers and barriers that influence the use of interactive consumer health information technology (health IT, i.e., technologies that provide consumers with tailored health information) by three specific populations, namely the elderly, those with chronic conditions or disabilities, and the underserved (e.g., minorities, low-income populations and medically underserved geographical regions). They identified and reviewed at least the abstract of nearly 10,000 articles. The review concluded that factors such as consumers' perception of benefit, convenience and integration into daily activities facilitated the successful use of health IT for these specific populations. Usage was also more successful if the interactions with a clinician were rapid and frequent, as well as if intervention could be delivered on technology that consumers used every day for other purposes.

In a study on the use of a health information system delivered via digital television called 'Health Living', Nicholas, Huntington, Williams, Monopoli and Gunter [42] have identified differences between the users and non-users of this technology. In the Birmingham area, 35,000 households were provided with access to the Living Health interactive channel for a pilot period of 6 months. Questionnaire data revealed that individuals from poorer households were more likely to report that the system was useful compared to individuals from higher-income areas. Furthermore, individuals with a greater experience of technology were more likely to find the navigation and menu structure easier. The evidence from this study also provided support for prior arguments that iTV may prove effective at reaching and attracting those social groups that other technologies may not reach. The Living Health system, for example, attracted more male than female users, especially those aged 55 years and over [41]. However, the authors suggested that further research was needed to find out the reasons behind these differences.

2 Research aim and questions

Unlike previous studies, which have focused on the factors influencing the successful use of interactive technologies that provide health information and tools that are patient-centred, this study placed particular emphasis on the adoption of interactive services aimed at improving people's wellbeing. In particular, this exploratory study aimed to investigate the attitudinal and motivational factors that might facilitate or inhibit the uptake and use of iTV-based CT applications by both young and older people and explored the profiles of potential users of such interactive applications. Findings from this study may also shed more light on the hurdles and barriers to the use of iTV as an alternative to the PC for delivering health-related services to specific target groups such as the elderly.

The key research questions for this study were as follows:

1. What factors facilitate and inhibit the adoption and use of iTV-based CT applications?
2. What are the profiles (e.g., attitudinal and demographics) of potential users of CT applications via iTV and to what extent are these profiles interested in accessing such applications?
3. To what extent are the attitudes expressed by respondents grouped in different profiles reflective of their current behaviour (e.g., level of participation in leisure activities and media and technology consumption)?

3 Method

To address the questions posed above, the present study aimed to generate a typology of propensity to adopt iTV-based CT. This was based on (a) attitudes towards leisure activities and a healthy lifestyle, as well as (b) attitudes towards media technology and iTV.

3.1 Sample

Two thousand and two hundred questionnaires were distributed as part of the Vital Mind (VM) project between May and August 2009 in different locations across London (UK). The primary fieldwork sites were London Victoria Coach Station, residential streets and recreation and social clubs. A copy of the survey was also available online via the surveymonkey website and publicised via community websites (e.g., gumtree.com) and 'snowballing' methods [15]. Participation in a prize draw was offered as an incentive to improve response rates. In total, there were 848 returns, giving a 39% response rate. Fifty-nine percent of the sample was female and 39% male (eight cases with missing sex data and 10 preferred not to answer). Thirty-five percent of the respondents were aged between 18 and 34 years; 13% between 35 and 49; 21% between 50 and 64; 23% between 65 and 80; and 4% were 80 years or older (six cases had missing age data and 19 preferred not to answer). With regards to education level, 8% of the sample had no formal qualifications, 14% had basic education (e.g., GCSE/O-Level), 22% had further education (e.g., A-Level/AS Level/IB, BTEC National/GNVQ, Diploma, City & Guilds), 51% higher education (e.g., B.Sc., B.A., B.Ed., M.Sc., M.A., PhD or other doctorate degrees), 3% had other education qualifications and 3% preferred not to answer. Forty-three percent of the respondents were married or living with partner, 36% were single (never married), 10% were widowed, 9% were divorced or separated and 1% preferred not to answer.

3.2 Measures

An initial list of 48 items measuring attitudes towards leisure and healthy activities and technology was developed. The items were derived from a literature review of relevant research in conjunction with feedback from two preliminary focus groups with older people conducted in 2008 at Goldsmiths, University of London. Preliminary analysis of the focus groups revealed that CT delivered via iTV may appeal to older people, especially those who are not computer literate and who lead a less active lifestyle. However, some of the oldest participants in the focus groups (people aged 80 years and over) reported that they were easily intimidated by new technology and innovations, and that they might have difficulty accepting new technology devices, especially if they are difficult to use and understand. The result of the focus groups also indicated that some participants would like these applications to be used as a means of social cohesion, to share activities with family members and friends in order to maintain a relationship with them. However, they also expressed doubts about the idea of communicating with people unfamiliar to them and had concerns about the privacy and security of their personal information [37].

The initial list of 48 items was tested in a pilot study on a sample of 16 respondents (aged 18–64), who were asked to comment on the wording of items, response formats and questionnaire layout. Seven out of 48 items were dropped from the original questionnaire as a result. The retained items resulted in a 41-item questionnaire consisting of two main attitude sections: (a) attitudes towards leisure activities and health (22 items: e.g., "I prefer outdoor activities to indoor activities"; "I worry about my health") and (b) attitudes towards technology, media consumption, and digital and interactive TV (19 items: e.g., "I enjoy playing with hi-tech products"; "I could enjoy playing games through interactive TV"). Some of the items in section b (e.g., "I don't consider TV to have any educational value") were derived from the ITC-Media and Technology Experience Questionnaire (ITC-MaTE) developed by Freeman et al. [17]. A seven-point Likert scale, ranging from 'strongly disagree' (1) to 'strongly agree' (7), was chosen as the response option for all items.

Other sections of the survey probed respondents for information on (a) the level of mental, physical and social activity they engaged in; (b) their use of and access to technology and media products/services (e.g., listening to music or radio, playing video games, surfing the internet); (c) their experience with brain-training games; and (d) their potential interest in iTV-based CT applications. The final section of the survey asked for demographic information (e.g., sex, age, marital status, living arrangement, income).

4 Results

The data analysis for this study was conducted in two main stages.

- First, a statistical data reduction procedure, principal component analysis (PCA), was applied to the 41 attitudinal statements of the survey to identify underlying factors that summarised the drivers and barriers to use of and engagement with iTV-based CT applications.
- Second, cluster analysis (CA) was used to identify clusters or groups of respondents who shared similar

profiles on the factors identified in the PCA. Finally, having performed both PCA and CA, it was then possible to analyse the media use, leisure activities and the interest in trying cognitive exercises through the television of each cluster, developing a richer typology of potential users of such services.

Statistical package for social science (SPSS) computer software version 14.0 for Window was used to analyse the data.

4.1 Principal component analysis

Data from the 41 attitudinal items were entered into a PCA with pairwise deletion for cases with missing values (i.e., all cases were included in the analysis in order to make full use of the dataset). PCA is conceptually similar to exploratory factor analysis (EFA), as they share methods for determining the number of components or factors to retain and they frequently produce similar results. For this reason, the terms 'component' and 'factor' will be used interchangeably.

Measures of sampling adequacy indicated that the correlation matrix for the 41-item questionnaire was suitable for PCA (Bartlett's Test of Sphericity $\chi^2 = 8{,}323.9$, $p < 0.001$; Kaiser–Meyer–Olkin measure of sampling adequacy $= 0.819$). Moreover, by examining the correlation matrix, a large number of significant correlations ($p < 0.001$) were found among all variables, indicating good factorability of the dataset.

The criterion of eigenvalue greater than one generated an 11-factor solution from the questionnaire items. Although this criterion is usually a good index to determine the number of factors to extract from a dataset with 40 or less items, in other circumstances, it can over- or under-estimate the number of factors [59]. In this instance, with 41 items, the number of factors was likely to be marginally overestimated and the 11-factor solution was considered unsuitable for the purpose of this research. A second criterion—elbows in the scree plot (i.e., plots of the ordered eigenvalues against their ranks)—was used to determine the number of factors to extract [2]. Although either a five-, six- or seven-factor solution was suggested by this criterion, the six-factor solution made the most conceptual sense. Items that failed to load 0.3 or higher on one factor, or that loaded greater than 0.3 on two or more factors, were then eliminated to maximise the distinctiveness of each factor. For the six-factor solution, all items loaded greater than 0.3 and one item—"I enjoy activities that demand high levels of concentration"—cross loaded on three different factors and it was thus removed. Subsequently, the PCA was re-run and the six-factor solution was forced producing meaningful and distinctive factors. Cumulatively, the six factors accounted for 42% of the variance in the data. The six factors were then subjected to varimax rotation, which is useful to identify uncorrelated latent factors.

4.1.1 Factor structure

Table 1 lists the items which loaded on each factor resulting from the PCA.

- The first factor (9 items) accounted for 10.5% of the variance in the survey items and indicated enthusiasm in exploring technology, especially interactive television. This factor was thus labelled 'technophilia' (e.g., "I like the idea that TV is becoming more functional").
- The second factor (9 items), labelled 'unprogressiveness', explained 7.7% of the variance. This factor reflected a tendency to be anxious about technology use (self-efficacy with respect to technology) and more sceptical, passive and pessimistic about their ability to change things, i.e., external locus of control (e.g., "There is nothing I can do to reduce the effects of ageing").
- The third factor (10 items), labelled 'health concern', explained 6.9% of the variance and indicated a tendency to be worried about one's own state of health (e.g., "I feel I should be doing more to lead a healthy lifestyle").
- The fourth factor (5 items) also accounted for 6.9% of the variance and it was exclusively characterised by items describing a negative perception of television (e.g., "Watching TV is a waste of my time"). This factor was thus labelled 'telly-negativity'.
- The fifth factor (3 items) explained 6.3% of the variance. The three items which loaded onto this factor related to a tendency or disposition to be healthy, active and enjoy a sense of wellbeing (e.g., "I make a point of keeping my mind and body active as I get older"). As such, this factor was labelled 'active wellbeing'.
- The sixth and final factor (4 items) explained 3.8% of the variance and indicated a relative tendency to be outgoing, sociable, easygoing and a preference for pastimes involving others and outdoor pursuits (e.g., "I prefer to spend time with others than by myself"). The factor was consequently labelled 'active sociability'.

4.1.2 Reliability of the factors

Cronbach's alpha was used to measure the internal consistency (reliability) of the factors. The alphas for the resultant factors ranged from 0.60 to 0.81, except for the sixth factor. Reliability analysis of this factor revealed an alpha score of 0.33. Several studies have indicated 0.6

Table 1 List of items for each factor and their factor loadings

Factor	Item	Loading
Technophilia	I enjoy exploring all the options that hi-tech products offer	.790
	I could enjoy playing games through interactive TV	.716
	I enjoy playing with hi-tech products	.711
	I like the idea that TV is becoming more functional	.644
	I feel confident using new technology	.592
	I think interactive TV is easy to use	.546
	I'm looking forward to using my TV more and more for things other than just watching programmes	.542
	Playing computer or video games can sharpen one's mind	.530
	I enjoy playing board games and/or cards with friends	.301
Unprogressiveness	When I use hi-tech products, I worry I will make an irreversible mistake	.651
	I often feel frustrated when using hi-tech products	.601
	I wouldn't know how to go about getting interactive TV, even if I wanted it	.520
	When it comes to my health, the less I think about it the better	.519
	I don't trust the internet with my personal data	.499
	I am usually not prepared to spend a lot of effort on challenging and difficult tasks	.447
	There is nothing I can do to reduce the effects of ageing	.388
	For sports, films or games I'd rather pay for what I watched (like the mobile phone deal, 'pay-as-you-go') rather than get a subscription	.363
	I would worry about becoming addicted to computer games	.323
Health concern	I worry about my health	.678
	I feel I should be doing more to lead a healthy lifestyle	.583
	I would like to be regularly informed about my state of health	.572
	I sometimes worry about becoming more forgetful	.531
	I would like to stimulate my mind more	.464
	I would like to spend more time with my family	.416
	It is important to me to keep busy	.416
	I sometimes feel lonely or socially isolated	.407
	I would worry about who sees my health records	.366
	I find it difficult to concentrate on a task without being distracted	.304
Telly-negativity	Watching TV is a waste of my time	.756
	TV does nothing to stimulate my brain	.738
	I don't consider TV to have any educational value	.725
	TV is good company	−.615
	Interactive TV does not interest me	.430
Active wellbeing	I generally try to live a healthy lifestyle	.769
	I make a point of keeping my mind and body active as I get older	.764
	I need encouragement to do physical activity	−.517
Active sociability	I prefer to spend time with others than by myself	.597
	I prefer outdoor activities to indoor activities	.551
	I enjoy pastimes that I can do on my own	−.463
	I don't mind looking foolish if I'm having fun	.461

[39] and 0.5 [12, 23] to be an acceptable reliability coefficient, but lower thresholds are sometimes used in the literature. When examining internal reliability coefficients, scepticism has been expressed about how the coefficients are calculated. Cronbach's alpha, for example, computes higher reliability coefficients when the number of scale items is higher. Therefore, the lower level of reliability for active sociability could have been due in part to the small number of items on this factor [58]. An acceptable level of reliability depends on the purpose of the research [44]. Given the exploratory nature and the purpose of this research (to identify

conceptually coherent factors), this lower level of reliability was accepted.

4.2 Cluster analysis

A two-step cluster analysis was conducted to identify meaningful groups of individuals in terms of their similarity in attitudes. The advantage of this technique over hierarchical and k-means clustering is that it scales efficiently when the dataset is very large [43]. The six factors along with age groups (five levels: 18–34, 35–49, 50–64, 65–79 and 80+) were entered as variables on which the respondents were 'clustered'.

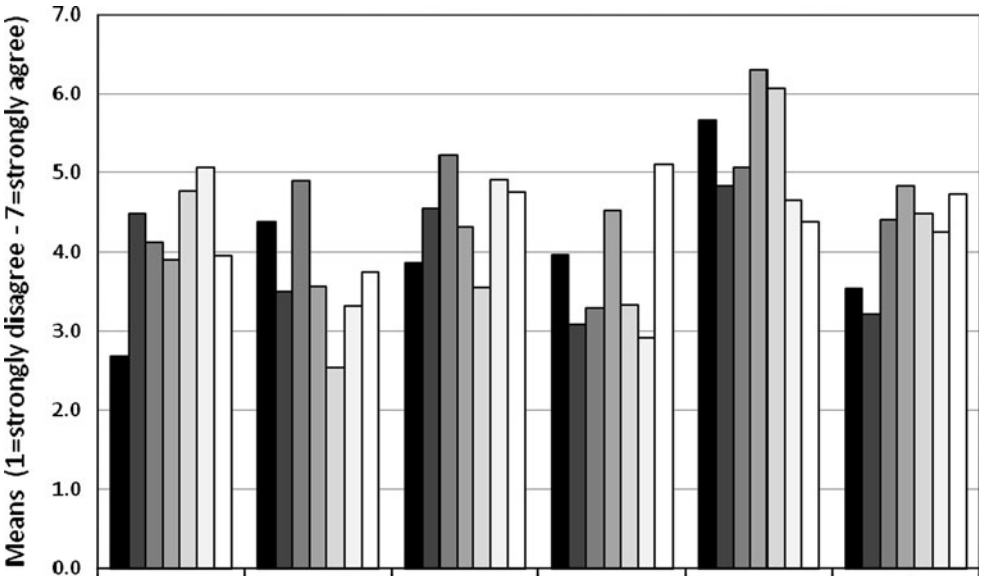
A first inspection of the cluster pie chart revealed two first-level clusters, which divided the sample into two groups according to age—younger and older than 50 years. However, the practical utility of such a small number of clusters is limited and a larger number of clusters were needed to represent adequately such a large sample. The goal was to discover a cluster solution that made both the most sense in reflecting the different attitudes and profiles of the respondents and had neither too few nor too many cases. After evaluating different solutions, a seven cluster solution was deemed to be the best representation of the structure for this set of data and made most conceptual sense. Compared with the five and six cluster solutions, this solution allowed for a greater differentiation among clusters without being overly fragmented and yielded enough cases in each group to perform statistical analyses.

The characteristics of each cluster across the seven factors are summarised in Fig. 1. Three of the clusters were predominantly older (aged 50 years and over), one was middle-aged (35–65 years) and another three were younger (aged 18–49 years).

4.2.1 Cluster profiles

The key characteristics and attributes that define each cluster are given below:

- *Cultured-Conservatives* (15% of the sample):
  Cultured-Conservatives tended to be the oldest of all the clusters (65 years and over). They scored high on active wellbeing but low on technophilia and health concern. They showed a tendency to reject engagement with media technology because of fear, low understanding, low trust and high effort. They were particularly averse to using their TV for anything other than traditional "sit back" viewing, of which they watched a more than average amount. However, they also liked to busy themselves with outdoor pursuits involving other people. Compared to the other clusters, and despite their older age, they were less concerned about their health, possibly because they considered that they already lead active and socially rich lifestyles.
- *Digital-Immigrants* (14% of the sample):
  Respondents classified as Digital-Immigrants tended to be the youngest of the three older groups (mostly aged 50–79 years). With high scores on technophilia, Digital-Immigrants represented respondents who saw benefits, and were open, to new technology, particularly new services for digital television. They were "looking forward to using their TV more and more for things other than just watching programmes". Members of this group appear to be moving with the times. They scored low on active wellbeing and were relatively passive, less outgoing and sociable than the Culture-Conservatives and valued TV for entertainment and stimulation.
- *Telly-Fans* (13% of the sample):
  Telly-Fans tended to be over 50 and were the second oldest cluster. Members of this group were heavy TV viewers and had a positive disposition towards TV. Telly-Fans tended to feel frustrated and to worry about making an irreversible mistake when they used hi-tech products. Scoring high on unprogressiveness, they were characterised by a tendency to be cautious, and somewhat neurotic and fearful of change, particularly with regard to new technology. Whilst they were somewhat active and sociable, they were also concerned about their physical and mental wellbeing, possibly recognising that their increasing age was associated with increases in health risks.
- *Busy-Interactors* (14% of the sample):
  Busy-Interactors tended to be middle-aged (35–64 years). They scored high on active wellbeing, active sociability and telly negativity but low on technophilia. As their name implies, they were primarily driven by keeping themselves active, healthy and connected with others. There was no time for Busy-Interactors to waste watching TV, which they perceived as low value and unstimulating. Similarly, exploration of new media technology, particularly new digital TV services, held little appeal, possibly because they had little time and preferred instead to be outdoors doing something.
- *Healthy-Strivers* (13% of the sample):
  Respondents classified as Healthy-Strivers tended to be young to middle-aged (18–49) and open to all experiences. Whilst they were similar to the Busy-Interactors in that they strived to lead a healthy, social and active lifestyle, they were also keen explorers of new technology and welcomed new applications for digital television. In fact, Healthy-Strivers scored high on active wellbeing, active sociability and technophilia. Possibly because they have grown up with technology



	Technophilia	Unprogressiveness	Health Concern	Telly-negativity	Active Wellbeing	Active Sociability
CC	2.7	4.4	3.9	4.0	5.7	3.5
DI	4.5	3.5	4.6	3.1	4.8	3.2
TF	4.1	4.9	5.2	3.3	5.1	4.4
BI	3.9	3.6	4.3	4.5	6.3	4.8
HS	4.8	2.5	3.6	3.3	6.1	4.5
DN	5.1	3.3	4.9	2.9	4.7	4.3
NG	4.0	3.7	4.8	5.1	4.4	4.7

Fig. 1 Cluster profiles across the six factors

and were aware of its functional benefits, they were not fearful or cautious about using it. A healthy but balanced lifestyle, encompassing indoor (including traditional TV viewing) and outdoor leisure pursuits, was key to this cluster.

- *Digital-Natives* (20% of the sample):
  Digital-Natives were similar in age range to the Healthy-Strivers (18–49 years). They loved exploring and engaging with technology. New functional possibilities afforded by digital television excited them, but they also valued TV as a traditional passive medium. Technology was viewed as an integral part of their lives and they enjoyed being part of a changing technology lifestyle. They were not resistant to change. Perhaps because of the dominating role of technology in their lives, they worried about their health and felt they should be doing more to lead a healthy lifestyle.
- *Net-Generation* (11% of the sample):
  Respondents classified as Net-Generation were the youngest of the clusters (18–34 years) and led a typically youthful lifestyle, rich with socialising with friends. Whilst they spent considerable time 'out and about', it was generally driven by a motivation to socialise rather than for health reasons. Nevertheless, they were concerned about their health. They were the Net-Generation—today's youth where physical and online connectivity (e.g., Facebook) with others are taken for granted. In their world, the internet had replaced TV for all manner of functions, and traditional TV was perceived as unstimulating and with no educational value. They placed very little overall value on TV, even if it were to offer additional functions.

In order to develop a richer typology of potential users of CT applications via iTV, clusters were explored for their (a) level of mental, physical and social activity; (b) time spent using different media technologies; and (c) interest in CT through TV.

4.3 Level of mental, physical and social activity

In order to validate some of the described characteristics of each cluster, the respondents' level of engagement in leisure activities was analysed. As part of the survey, respondents were asked to report the frequency with which they engaged with (a) activities that stimulate the mind (for which the following examples were given: "reading", "doing puzzles", "playing cards", "playing board games", "creative hobbies", "attending classes or lectures", "other—

please specify"); (b) physical activities (i.e., "outdoor walking", "jogging or running", "bicycle riding", "sport activities", "physical work", "other, please specify"); and (c) social activities (i.e., "going out with friends/relatives", "inviting friends/relatives over", "visiting any interest group, club or association—please specify", "other—please specify"). Response options were 'daily' (5), 'weekly' (4), 'monthly' (3), 'less frequently' (2) or 'never' (1). In order to obtain a proxy for level of each activity, responses for each of the three questions (mental, physical, social), whose distributions followed a normal curve, were split into terciles (mental activities: ≤ 2.66 = low, 2.67–3.28 = medium, ≥ 3.29 = high; physical activity: ≤ 2.59 = low, 2.60–3.20 = medium, ≥ 3.21 = high; social activity: ≤ 2.99 = low, 3.00–3.66 = medium, ≥ 3.67 = high). This produced three groups of approximately equal numbers of people corresponding to those who engaged in low, medium and high levels of each activity.

In terms of level of mental activity, on average, 36% of the whole sample was categorised as having a high level of mental activity. The Healthy-Strivers was the only cluster strongly over-indexed (i.e., higher than average) on this activity (42%). However, a one-way analysis of variance (ANOVA) performed on the mean ratings for the level of mental activity revealed no statically significant differences among the clusters.

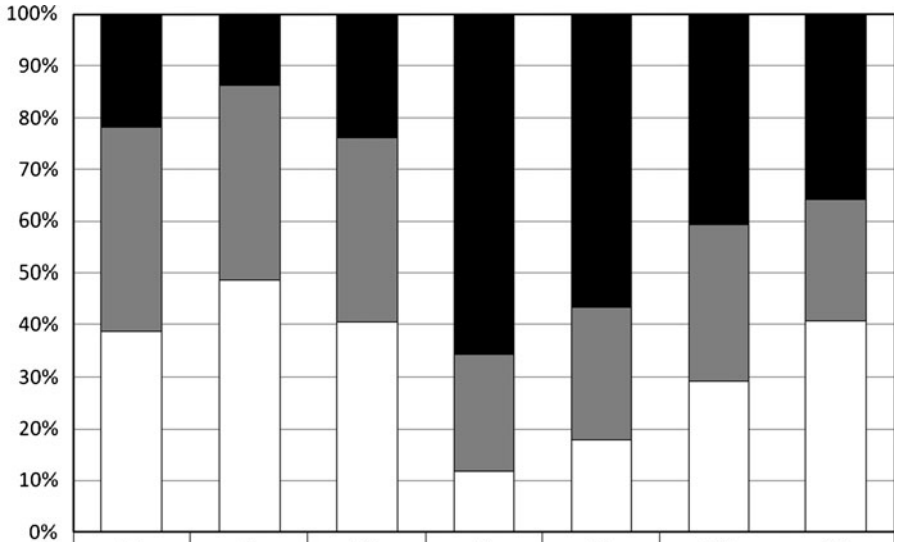
With regards to physical activity, approximately 37% of the whole sample reported a high level of engagement in this activity. Busy-Interactors were by far the most engaged cluster on this activity (66%), followed by Healthy-Strivers (57%) and Digital-Natives (41%). In contrast, Digital-Immigrants (14%), Cultured-Conservatives (22%) and Telly-Fans (24%) were strongly below-index on this activity (Fig. 2). A one-way ANOVA used to test for between-cluster differences on the level of physical activity revealed significant differences between the clusters, $F(6, 803) = 18.8$, $p < 0.001$, $\eta p^2 = 0.115$. The post hoc tests (Bonferroni) revealed that the level of physical activity of Busy-Interactors was significantly higher than those of any other cluster ($p < 0.05$). No other differences between the clusters were significant.

Finally, about 27% of the whole sample reported a high level of social activity. Net-Generation and Healthy-Strivers reported the highest level on this type of activity (32 and 29%, respectively), whilst Digital-Immigrants reported the lowest level on this activity (24%). However, one-way ANOVA indicated no statistically significant differences in the mean values between the clusters.

These findings provide some validation for the results that emerged from the Cluster Analysis. In particular, clusters with the highest factor scores in active wellbeing—Healthy-Strivers and Busy-Interactors—were the clusters which reportedly engaged most frequently in mental and physical activities. Similarly, Net-Generation, which reported the highest level of social activity, was also among the clusters with the highest score in active sociability.

4.4 Media and technology use

Separate survey questions probed respondents for the hours they engaged in everyday media and technology activities. In particular, participants reported the time spent on



	CC	DI	TF	BI	HS	DN	NG
High level	21.8%	13.8%	23.9%	65.8%	56.6%	40.6%	36.0%
Medium level	39.5%	37.6%	35.8%	22.5%	25.5%	30.3%	23.3%
Low level	38.7%	48.6%	40.4%	11.7%	17.9%	29.1%	40.7%

Fig. 2 Rates of level of physical activity by cluster (*CC* cultured-conservatives, *DI* digital-immigrants, *TF* telly-fans, *BI* busy-interactors, *HS* healthy-strivers, *DN* digital-natives, *NG* net-generation)

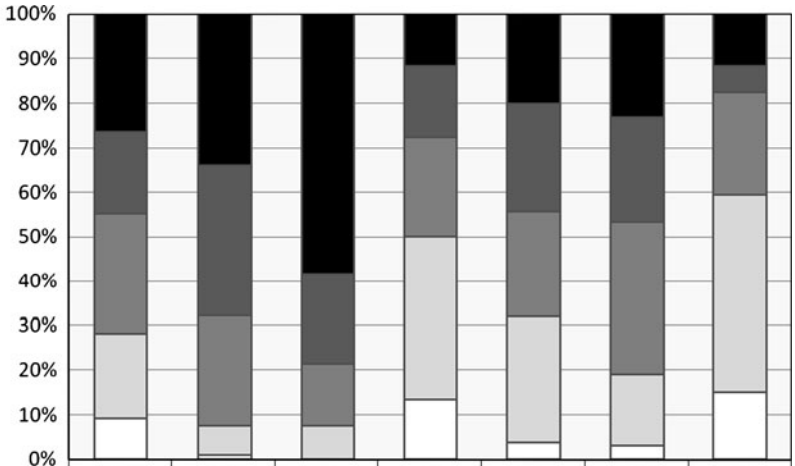
"watching television", "listening to music or radio", "playing video/computer games", "using the computer (not gaming)" and "surfing the internet" by choosing one of the following response options: 'none', 'less than 1 h a day', '1–2 h a day', '2–3 h a day' and '3 h a day or more'. The results revealed a different trend in the type of media and technology activities undertaken between younger and older clusters. Specifically, whilst older clusters were more likely to regularly watch TV, younger clusters tended to use more advanced technology devices, such as the computer or game console. On average, about 40% of people across the three oldest clusters—Cultured-Conservatives, Telly-Fans and Digital-Immigrants—reported spending more than 3 h in front of the TV screen (relative to 17% across the other clusters), whilst only 13% of them spent the same amount of time using the computer (relative to 42% across the other clusters). These results are broadly consistent with recent UK statistics on media use, which show that older people are more likely to regularly use traditional media such as watching television than to participate in other electronic media activities [45]. A series of one-way ANOVAs was used to test for between-group differences in the responses to the questions on use of media and technology. Furthermore, post hoc tests (Bonferroni) were used to explore the main effect of cluster.

4.4.1 Watching television

The ANOVA revealed significant differences between the seven clusters for the time people reported to spend watching TV, $F(6, 796) = 29.6$, $p < 0.001$, $\eta p^2 = 0.182$. Post hoc analyses confirmed that Telly-Fans were the heaviest users of television. The average time spent on this activity was significantly higher for this cluster ($p < 0.05$) when compared to that of any other cluster, and significantly lower for Busy-Interactors ($p < 0.05$) and Net-Generation ($p < 0.05$). Approximately 58% of Telly-Fans reported watching TV for three or more hours a day, compared to only 12% of both Busy-Interactors and Net-Generation (Fig. 3). Bonferroni tests also revealed that Digital-Immigrants reported spending significantly more time watching TV than Cultured-Conservatives ($p < 0.05$), Healthy-Strivers ($p < 0.05$) and Digital-Natives ($p < 0.05$). However, no statistically significant differences were found between these last three clusters.

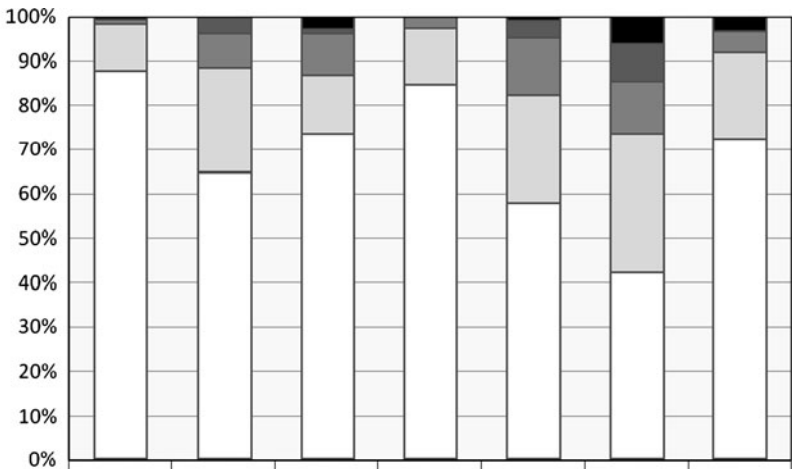
4.4.2 Listening to music or radio

On average, a quarter of the sample as a whole reported listening to music or radio for three or more hours a day. The ANOVA revealed no significant differences between the clusters for the time people reported spending on this activity.



	CC	DI	TF	BI	HS	DN	NG
More than 3 hours a day	26.45%	33.94%	58.33%	11.61%	20.19%	23.31%	11.63%
2-3 hours a day	18.18%	33.94%	20.37%	16.07%	24.04%	23.31%	5.81%
1-2 hours a day	27.27%	24.77%	13.89%	22.32%	24.04%	34.36%	23.26%
Less than 1 hour a day	19.01%	6.42%	7.41%	36.61%	27.88%	15.95%	44.19%
None	9.09%	0.92%	0.00%	13.39%	3.85%	3.07%	15.12%

Fig. 3 Rates of daily time spent on watching TV by cluster (*CC* cultured-conservatives, *DI* digital-immigrants, *TF* telly-fans, *BI* busy-interactors, *HS* healthy-strivers, *DN* digital-natives, *NG* net-generation)



	CC	DI	TF	BI	HS	DN	NG
More than 3 hours a day	0.82%	0.00%	2.83%	0.00%	0.98%	6.13%	3.45%
2-3 hours a day	0.00%	3.81%	0.94%	0.00%	3.92%	8.59%	0.00%
1-2 hours a day	0.82%	7.62%	9.43%	2.73%	12.75%	11.66%	4.60%
Less than 1 hour a day	10.66%	23.81%	13.21%	12.73%	24.51%	31.29%	19.54%
None	87.70%	64.76%	73.58%	84.55%	57.84%	42.33%	72.41%

Fig. 4 Rates of daily time spent on playing video/computer games use by cluster (*CC* cultured-conservatives, *DI* digital-immigrants, *TF* telly-fans, *BI* busy-interactors, *HS* healthy-strivers, *DN* digital-natives, *NG* net-generation)

4.4.3 Playing video/computer games

Statistically significant differences were found between the clusters for the time people reported to spend playing video/computer games, $F(6, 788) = 17.2$, $p < 0.001$, $\eta p^2 = 0.116$. Post hoc analyses indicated that the average time spent on this activity was significantly higher for Digital-Natives ($p < 0.05$) when compared to that of any other cluster, and for Healthy-Strivers when compared to Cultured-Conservatives ($p < 0.05$) and Busy-Interactors ($p < 0.05$). Healthy-Strivers and Digital-Natives were the most engaged clusters on this activity, with 26 and 18% of them playing video/computer games for one or more hours a day, respectively (Fig. 4). Conversely, Cultured-Conservatives and Busy-Interactors tended to spend the least amount of time playing video or computer games, with, respectively, 98 and 97% of the members of these clusters reporting to play games less than 1 h a day or not at all.

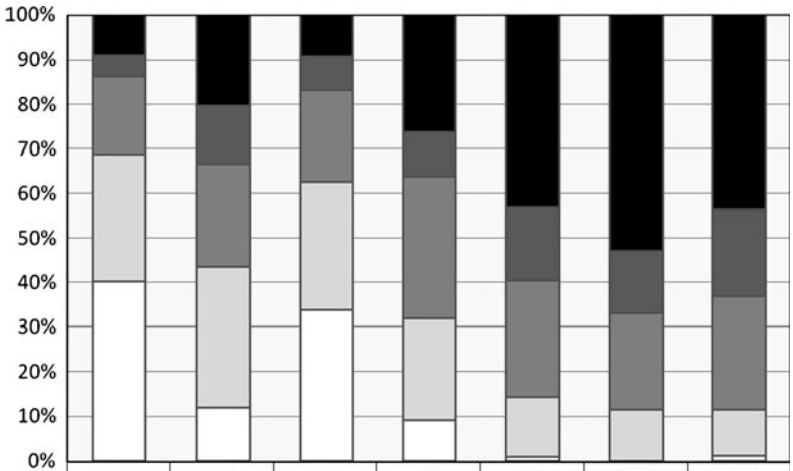
Survey participants were also asked to report their previous experience with brain-training games. Of the people who answered the question "do/did you play brain training games?" ($n = 456$, 392 missing data), 31% reported to have played such games before. However, no significant differences were found between the clusters.

4.4.4 Using the computer (not gaming)

The amount of time that people reported using the computer (not gaming) also differed significantly, as indicated by a main effect of cluster, $F(6, 795) = 50.6$, $p < 0.001$, $\eta p^2 = 0.277$. Post hoc analyses indicated that the average time spent on this activity was significantly higher for the three youngest clusters when compared to that of any other cluster ($p < 0.05$). In particular, 53% of Digital-Natives reported to spend three or more hours a day in front of the computer, followed by 44% Net-Generation and 43% Healthy-Strivers (Fig. 5). Conversely, Cultured-Conservatives and Telly-Fans were significantly the least engaged on this activity compared to all other clusters ($p < 0.05$), with only 9% of them reporting to use the computer for three or more hours a day. The amount of time spent by Digital-Immigrants and Busy-Interactors in front of the computer was also significantly different when compared to that of any other cluster ($p < 0.05$), with 26% of Busy-Interactors and 20% of Digital-Immigrants using the computer for three or more hours a day. However, no significant differences were found between these two clusters.

4.4.5 Surfing the internet

Finally, an ANOVA showed a significant difference between clusters for surfing the internet, $F(6, 799) = 76.0$, $p < 0.001$, $\eta p^2 = 0.363$. As expected, post hoc tests indicated a similar pattern of results to those observed for "using the computer". The average time spent on this activity was significantly higher for Digital-Natives ($p < 0.05$) when compared to that of any other cluster,



	CC	DI	TF	BI	HS	DN	NG
More than 3 hours a day	9.02%	20.37%	9.35%	26.36%	43.27%	53.05%	43.68%
2-3 hours a day	4.92%	12.96%	7.48%	10.00%	16.35%	14.02%	19.54%
1-2 hours a day	17.21%	23.15%	20.56%	31.82%	25.96%	21.34%	25.29%
Less than 1 hour a day	28.69%	31.48%	28.97%	22.73%	13.46%	10.98%	10.34%
None	40.16%	12.04%	33.64%	9.09%	0.96%	0.61%	1.15%

Fig. 5 Rates of daily time spent on using the computer (not gaming) by cluster (*CC* cultured-conservatives, *DI* digital-immigrants, *TF* telly-fans, *BI* busy-interactors, *HS* healthy-strivers, *DN* digital-natives, *NG* net-generation)

followed by Net-Generation ($p < 0.05$) and Healthy-Strivers ($p < 0.05$). As shown in Fig. 6, 87% of Digital-Natives reported surfing the internet for three or more hours a day, compared to 80% of Net-Generation and 74% of Healthy-Strivers. Conversely, Cultured-Conservatives and Telly-Fans were significantly the least engaged on this activity compared to all other clusters ($p < 0.05$), with only 12 and 20% of them respectively reporting to surf the internet for three or more hours a day.

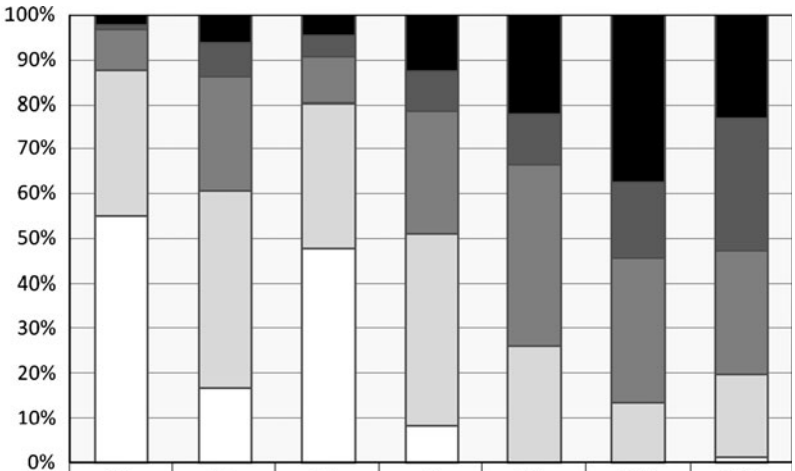
4.5 Interest in cognitive training through TV

Finally, participants were asked about their interest in trying CT applications through their television. Response options to the question "If you were offered easy access through your television to engaging exercises that are scientifically designed to train certain functions of the brain, such as memory, attention, etc., how likely would you be to try the service?" ranged from 'very unlikely to try' (1) to 'very likely to try' (5). Of the people who answered this question ($n = 821$, 27 missing data), 74.3% reported that they would be 'likely' or 'very likely' to try CT exercises in at least one of the following contexts: "by themselves" (69%), "with friends or relatives in the same room" (58%), "with friends or relatives online" (26%) or "with strangers online" (11%). A series of one-way ANOVAs revealed significant differences between the clusters in their interest for each of the four aforementioned contexts, respectively, $F(6, 788) = 12.3$, $p < 0.001$, $\eta p^2 = 0.087$; $F(6,734) = 17.0$, $\eta p^2 = 0.122$, $p < 0.001$; $F(6, 702) = 15.4$, $p < 0.001$, $\eta p^2 = 0.116$; $F(6, 703) = 14.1$; $p < 0.001$), $\eta p^2 = 0.107$.

Bonferroni post hoc analyses indicated that Digital-Natives were significantly more interested in trying CT exercises via iTV than any other cluster ($p < 0.05$) in three of the contexts reported above ("with friends or relatives in the same room", "with friends or relatives online" and "with strangers online"). Although members of this cluster reported also the highest interest in trying CT by themselves, this was not significantly different from the level of interest expressed by Telly-Fans, Digital-Immigrants and Healthy-Strivers. Not surprisingly, all clusters showed a similar pattern of preferences, with the option "by myself" being the most preferred choice by all clusters and "with strangers online" being the least preferred (Fig. 7). Conversely, Cultured-Conservatives were significantly the least interested in trying CT "by themselves" compared to any other cluster ($p < 0.05$), "with friends or relatives in the same room" ($p < 0.05$) and "with friends or relatives online" ($p < 0.05$). Whilst this cluster was also the least interested in trying CT "with strangers online", this was not significantly different from the level of interest of Digital-Immigrants and Busy-Interactors.

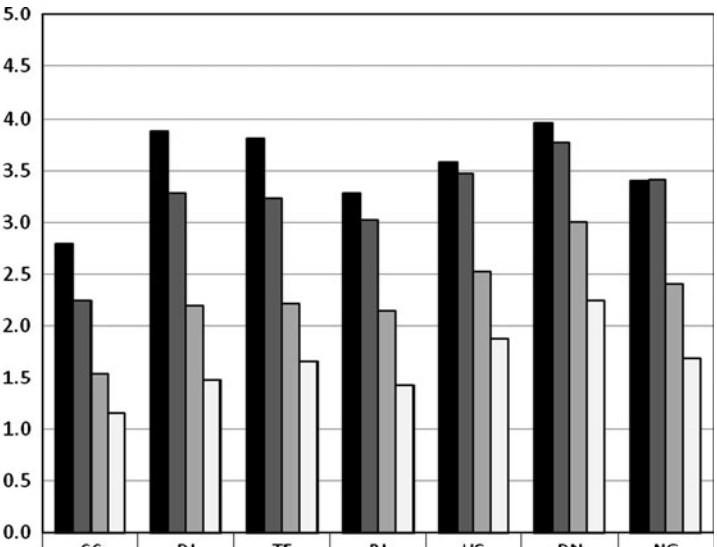
A one-way ANOVA was also conducted to determine whether there was a significant difference between age groups on the reported interested in CT. However, the analysis revealed no significant effect of age groups on this response.

A multiple linear regression analysis was performed to determine which of the six factors emerging from the PCA were the best predictors of interest in CT. The six factors accounted for approximately one-fifth of the variance in scores on CT interest ($R^2 = 0.21$), which was highly



	CC	DI	TF	BI	HS	DN	NG
More than 3 hours a day	2.46%	6.42%	4.67%	12.50%	22.12%	37.58%	22.99%
2-3 hours a day	0.82%	7.34%	4.67%	8.93%	11.54%	16.97%	29.89%
1-2 hours a day	9.02%	25.69%	10.28%	27.68%	40.38%	32.12%	27.59%
Less than 1 hour a day	32.79%	44.04%	32.71%	42.86%	25.96%	13.33%	18.39%
None	54.92%	16.51%	47.66%	8.04%	0.00%	0.00%	1.15%

Fig. 6 Rates of daily time spent on surfing the internet by cluster (*CC* cultured-conservatives, *DI* digital-immigrants, *TF* telly-fans, *BI* busy-interactors, *HS* healthy-strivers, *DN* digital-natives, *NG* net-generation)



	CC	DI	TF	BI	HS	DN	NG
By myself	2.8	3.9	3.8	3.3	3.6	4.0	3.4
With friends/relatives in the same room	2.2	3.3	3.2	3.0	3.5	3.8	3.4
With friends/relatives online	1.5	2.2	2.2	2.1	2.5	3.0	2.4
With strangers online	1.2	1.5	1.7	1.4	1.9	2.2	1.7

Fig. 7 Mean interest in cognitive training through TV by cluster (*CC* cultured-conservatives, *DI* digital-immigrants, *TF* telly-fans, *BI* busy-interactors, *HS* healthy-strivers, *DN* digital-natives, *NG* net-generation)

significant, $F(6, 807) = 36.3$, $p < 0.001$. Technophilia ($\beta = 0.40$, $p < 0.001$) and health concern ($\beta = 0.11$, $p < 0.001$) were the most influential predictors, followed by active sociability ($\beta = 0.72$, $p < 0.05$). Active wellbeing ($\beta = -.02$, $p = 0.503$), unprogressiveness ($\beta = -.04$, $p = 0.280$) and telly-negativity ($\beta = -.06$, $p = 0.085$) were not significant factors.

Finally, the seven clusters were plotted against the two most influential factors in a bubble chart (Fig. 8) in order to provide a clearer picture of the target market for iTV-based CT applications. Clusters to the right in this chart have higher scores on health concern, and clusters towards the top have higher scores on technophilia. Additionally, the size (area or radius) of the bubble indicates cluster size.

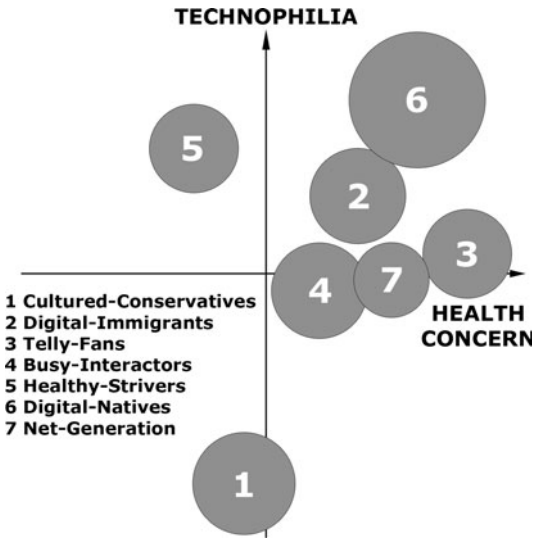


Fig. 8 Bubble chart displaying the seven clusters as measured by cluster size (the bigger the bubble, the larger the size of the cluster), technophilia (the further up in the graph, the higher the score on technophilia) and health concern (the further to the *right* in the graph, the higher the score on health concern)

This chart indicates that of all the clusters Digital-Natives and Digital-Immigrants could be considered as the primary target market for iTV-based CT programs. Telly-Fans and Net-Generation also reported a high interest in trying cognitive exercise through television, but unlike Digital-Natives and Digital-Immigrants, these two clusters might not be driven by the curiosity in new technology but simply because they feel they should be doing more to lead a healthy lifestyle and would like to stimulate their mind more because they worry about becoming more forgetful. Conversely, the oldest of all the clusters—Cultured-Conservatives—was the least interested in CT exercises through television possibly because members of this cluster were less 'curious' about new technology, and among the clusters were least concerned about their own state of health.

5 Discussion

The research presented here is the first attempt the authors are aware of to investigate the interest and profile of potential users of iTV-based CT applications among both younger and older people. In order to address the research objectives, an exploratory analysis based on attitudes towards leisure and health, as well as attitudes towards media, technology and iTV, was adopted. This approach identified six factors which may influence the adoption and use of CT through television. High scores on factors labelled as active wellbeing, health concern and technophilia would indicate potential drivers, and low scores potential barriers, to iTV-based CT applications uptake and use. Conversely, high scores on unprogressiveness and telly-negativity could indicate potential barriers, and low scores potential drivers, of uptake and use of such services. However, these barriers may be mitigated somewhat by the characteristics of iTV. In terms of unprogressiveness, the concerns of people who are not computer literate or do not feel confident in using new technology (members of clusters such as Cultured-Conservatives and Telly-Fans) are somewhat lessened by using a more familiar and accessible device such as the television. In terms of telly-negativity, the items that loaded on this factor relate largely to people's preconceptions of television as a traditionally passive medium (e.g., "TV does nothing to stimulate my mind"). High scores may indicate that the current content of TV does not satisfy these consumers' needs and, therefore, alternative, interactive and more 'useful' content may be attractive to high scorers on telly-negativity. Overcoming the barrier of unprogressiveness (for members of clusters such as Cultured-Conservatives and Telly-Fans) might be achieved by making the hardware and software very accessible and easy-to use but also by convincing these users that the CT really does provide benefits (or perhaps playing down the subject of cognitive decline altogether) and making sure the program is fun rather than effortful.

With regard to active sociability, a person who scores high on this factor would tend to prefer pastimes that he/she can do outdoors and with others, rather than to stay indoors in front of the TV screen. This factor was also characterised by items describing a tendency to be outgoing and extroverted (e.g., "I prefer to spend time with others than by myself"; "I don't mind looking foolish if I'm having fun"). For this reason, it can be argued that the role of active sociability as a driver or barrier will depend on how socially oriented iTV CT applications will become. A very sociable person may prefer to engage in CT activities with other people rather than train alone, especially if the time commitment is high.

Another interesting finding of this study was that, although older people are generally less familiar with technology than younger people, given the opportunity, a substantial proportion (71%) of the three oldest clusters—cultured-conservatives, digital-immigrants and Telly-Fans—reported interest in accessing cognitive exercise through their television. Digital-Immigrants and Telly-Fans appeared to be the most likely to adopt and use such applications, but for different reasons. For Digital-Immigrants, the adoption might be driven by a strong enthusiasm for technology, especially iTV (i.e., technophilia); whilst for Telly-Fans, the tendency to be worried about

their own state of health (i.e., health concern) might act as a driver for accessing CT through TV. Younger clusters such as Digital-Natives and Healthy-Strivers also showed high level of interest in this service. These findings indicate that brain-training-like programs are very popular with consumers and suggest that there is interest in them among both younger and older generations. Evidence of this is also provided by the findings on previous experience with brain-training games. Almost a third of the people who answered the question reported to have played such games before. Yet, as would be expected, this proportion drops with the increasing age of the respondents. This may relate to the fact that younger people spend more time in front of the computer, and thus have more access to computerised brain-training programs.

To conclude, the research presented in this paper has provided a refined understanding of the drivers and hurdles, particularly for older people, to the adoption of interactive services aimed at improving people's wellbeing. As such, the research should be of interest to researchers, health practitioners, public policy makers, designers and decision-makers on technology adoption, especially in relation to iTV features and services. Furthermore, utilising a combination of both demographic (i.e., age) and psychographic (i.e., attitudes) variables, this study provides more information to understand the profiles of each market segment and provides marketers with new insights into the drivers and barriers to the adoption of iTV-based CT applications for each targeted segment.

The research suggested a high level of interest across all age groups in accessing such CT services. Research suggests that demographic factors such as age may influence extreme and positive responding in self-report [26, 33, 56] and, in particular, that positive response bias increases with the age of the respondent [52]. For this reason, one may think that the results on CT interest are different as a function of the distribution of age groups within each of the profiles. However, the non-significant main effect of age groups detected by the ANOVA indicated that the differences in the rate of CT interest are not significantly influenced by the different age of the clusters.

Coupled with existing evidence on the benefits of computerised cognitive exercises, the findings reported here indicate that the TV could be the familiar and friendly device through which older people, among others, might easily access such interactive services to keep their minds active. Future research comparing user's motivations and interest in iTV-based CT applications with perceptions and acceptance postimplementation will contribute further understanding of the key factors influencing adoption and use of such applications, and their potential users.

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