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The technology profile inventory: Construction, validation, and application

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ABSTRACT

The technology profile inventory (TPI) measures attitudes toward computers and the internet. We describe the most recent phase of the construction of the TPI. The studies reported refine and validate the instrument, and we present the final version as an Appendix A. Using a new sample of respondents ($N = 394$), we replicated the three major factors found previously (Confidence, Approval, and Interest). The TPI scores were related to patterns of information technology (IT) usage and also to gender. To demonstrate the practical utility of the TPI we report (1) results linking TPI scores to behavior during an internet search task; (2) test–retest results obtained as part of a cognitive training experiment using action video games; and (3) results showing that attitudes to IT may be modified by a particular experience with information technology.

1. Introduction

DeYoung and Spence (2004) proposed the notion of a technology profile that is analogous to a personality profile. Much as a personality profile helps predict how individuals are likely to respond to various situations in everyday life, a technology profile is intended to characterize and predict how individuals are likely to respond to various aspects of information technology (IT). Although similar to the personality profile, the technology profile is more concerned with attitudes that may change with experience, rather than with the fundamental, relatively enduring traits that make up personality. Attitudes to computers affect behavior (Levine & Donitsa-Schmidt, 1998) and, in turn, influence people's use of computers. Thus a reliable measure of individual differences in attitudes to IT can be of value in the field of human–computer interaction (HCI). Knowing an individual's technology profile can help HCI researchers to separate the specific effects of the IT situation from the contribution of individual differences. To take a simple example, a user who is negatively disposed toward IT is likely to respond differently when using a computer, compared to a user who is comfortable with IT. DeYoung and Spence (2004) introduced a preliminary version of the Technology Profile Inventory (TPI); the studies reported here refine and validate the instrument, and a final version of the TPI is presented as an Appendix A.

1.1. Existing measures

The first computer attitude scales (e.g. Loyd & Gressard, 1984; Nickell & Pinto, 1986; Popovich, Hyde, Zakrajsek, & Blumer, 1987) were constructed more than two decades ago when personal computers were much less common and the World Wide Web (www) was still several years in the future. Today, computers and the www are so thoroughly integrated into the functioning of society that it is difficult to find educated persons who do not use computers, even if their purpose is only to send and receive email. A comprehensive measure of computer attitudes must reflect these changes; new instruments that are intended to capture responses to a broad spectrum of IT must include items pertaining to internet use. The original computer attitude scales did not do this and are therefore dated.

Over the past three decades, various factors that might affect an individual's attitude to IT have been proposed and discussed by several authors; however, a review by Smith, Caputi, and Rawstorne (2000) concluded that there is little agreement regarding the structure of attitudes toward computers. Although most empirical studies agree that there are no more than three or four dominant factors, these have been given different names by different investigators. Furthermore, many of the less salient factors reported in previous studies have accounted for relatively small proportions of variance and are thus likely to be of interest to niche audiences only. Nonetheless, a few common themes can be identified across studies (DeYoung & Spence, 2004; Levine & Donitsa-Schmidt, 1998; Loyd & Gressard., 1984; Bear, Richards, & Lancaster, 1987; Gardner, Dukes, & Discenza, 1993; Yang & Lester, 2003; Liaw, 2002; Whitley, 1996a); based on a reading of previous work,

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DeYoung and Spence (2004) proposed that the three dominant factors found by most investigators may be characterized as *Confidence* (vs. anxiety), *Approval*, and *Interest confidence* (*as opposed to anxiety*).

1.1.1. Confidence (as opposed to anxiety)

Research on attitudes to computers has often focused on anxiety. Chua, Chen, and Wong (1999, p. 610) defined computer anxiety as "a fear for computers when using the computer, or when considering the possibility of computer use." About two decades ago, labels such as "computerphobia" (Jay, 1981) and "computer aversion" (Meier, 1985) were in common use to describe a negative emotional response to computers. This aversion was thought to be the predominant reaction of many people and the focus on anxiety led to several studies that examined the correlates (e.g., gender, learning style), causes (e.g., lack of computer literacy), and effects (e.g., avoidance of computers) of computer anxiety (e.g., Barbeite & Weiss, 2003; Beckers & Schmidt, 2001; Chua et al., 1999; Coffin & MacIntyre, 1999).

Most early instruments included items designed to assess anxiety and related constructs (Loyd & Gressard, 1984; Nickell & Pinto, 1986; Popovich et al., 1987). However, by the mid-nineties, a more nuanced and balanced view was emerging to accommodate the rapidly changing realities of computer use. For example, Whitley (1996a,b) suggested that computer attitudes were driven by three general factors: computer anxiety/confidence, positive beliefs about computers, and negative beliefs about computers.

Computers and the internet have now become so familiar that anxiety is no longer the predominant emotion mentioned when people discuss their feelings regarding IT. There is more to the human response to IT than anxiety, which is merely one trait out of many that might be important in our relationships with computers. Indeed, we are now much more likely to refer to an individual's confidence when working with computers and the internet – the number of truly anxious users of technology has dropped markedly in recent years (Smith & Oosthuizen, 2006). There is a general recognition that the full range and complexity of human personality has become engaged in our interactions with the artificial world of IT and that a number of factors other than confidence/anxiety determine our feelings toward computers and IT.

1.1.2. Approval

Kay (1989, 1993) constructed a *Computer Attitude Measure* (*CAM*) which proposed that attitudes toward computers are mainly defined by feelings of favorableness or unfavorableness and that these feelings, in turn, are composed of four components – cognitive, affective, behavioral, and perceived control. The cognitive component focuses on belief; the affective component concerns liking; the behavioral component relates to activities in IT; and the fourth component considers "the perceived ease or difficulty of performing a particular behavior" (Kay, 1993, p. 372).

Liaw (2002) developed a survey instrument with two scales intended to measure attitudes toward the computer and the internet. A positive correlation between students' attitudes toward computers and toward the internet was observed. This suggests that attitudes to computers and attitudes to the internet can provide reciprocal concurrent validity. This study also showed that males had more positive perceptions toward computer and web technologies. When students had more years of computer-related experience, they also had more positive perceptions of computer and web technologies. Yang and Lester (2003) observed that both of Liaw's scales had a clear *Confidence* factor (Factor III) and their analysis also suggested that an *Approval* factor was present in both scales (Factor II), although Yang and Lester (2003) did not explicitly name this factor. Significantly, Liaw (2002) concluded that if users do not hold positive attitudes (approval) toward IT, then little else matters. Bozionelos (2001) expressed a similar sentiment and noted that the more contact people have with computers, the more likely they are to express approval. DeYoung and Spence (2004, p. 61) described *Approval* as "a positive attitude toward the functions and uses of IT"; thus, *Approval* reflects the degree to which people feel positively about IT as a tool to accomplish various ends, such as surfing the internet, sending email, instant messaging, social networking, reconciling accounts, or arranging their photo collections.

1.1.3. Interest

On the basis of their analyses, DeYoung and Spence (2004) proposed a separation of the "liking" or "positive attitude" factor found by others (e.g. Kay, 1989, 1993; Liaw, 2002) into two factors: *Approval* and *Interest*. Our present data also suggest that such a separation makes sense. We distinguish an affective attitude toward IT (*Approval*) from an attitude toward IT that is based on its intrinsic interest (*Interest*). We consider that it is possible to approve of IT and its many uses without necessarily being much interested in the details of how it works. Conversely, there are individuals who find IT interesting but do not have strong likes or dislikes regarding IT.

1.2. Need for a simple, comprehensive, and up-to-date measure

Attitudes toward computers and the internet likely have considerable influence on variables like computer use, computer literacy, the efficiency of computer-based learning, and career choices. Individual differences are not likely to be random but rather to be systematic. For example, men may hold different attitudes than women; the young will likely differ from the old; educational level may play a role; ethnicity and religious affiliation may be associated with different attitudes and behaviors; and so forth. If we are to investigate almost any aspect of behavior in the IT environment, it is prudent to assess the attitudes of the individuals studied using an instrument like the TPI. Some examples of individual differences variables that are of interest in HCI include:

1.2.1. Gender

It is important to be able to track changing male-female attitudes (Whitley, 1996a; Yoder and Herrmann, 2005) for several reasons. One of the most important issues is related to the underrepresentation of women in IT. Participation of women in the IT sector is very low worldwide. In industrialized countries only one in four jobs in IT is held by a woman and the situation is worse in the developing world. This is regrettable in both human and economic terms. Many researchers have proposed that individual differences in attitudes are at least partly responsible for low participation rates in IT, with women's attitudes toward IT thought to be less favorable than those of men. Although early education, socialization, and discrimination have frequently been suggested as possible contributory factors, there is a conspicuous lack of accurate and timely baseline data regarding individual differences in attitudes. Such knowledge is critical to guide the design of remedial initiatives. Despite the existence of a considerable literature, our knowledge of women's attitudes to IT is surprisingly meager, with good empirical data and theory lacking. To improve our understanding, we must measure and track the attitudes of women (and men) to IT.

1.2.2. Age

In North America and Europe, the average age of computer users is rising and this demographic change brings with it an increase in impairments and disabilities that affect computer use (Forrester Research, 2004). Aging is also sometimes accompanied by significant changes in personality, independently of changes in cognitive abilities, and these may represent barriers to the productive use of IT (Cuttler & Graf, 2007). Such obstacles to use will have an influence on attitudes toward IT and it is important to be able to track these attitudes so that potential changes in interface design or amendments to consumer legislation can be based on a solid foundation of fact. It will be important to determine the contribution of age-related changes in personality and attitudes as distinct from age-related changes in cognitive abilities.

1.2.3. Socio-economic status (SES)

Bozionelos (2004) has examined the relationships among SES, the amount of computer use, computer experience, and computer anxiety, showing that SES has a positive association with computer experience and a negative relationship with computer anxiety. This has profound implications. IT may be helping to widen divisions in society and also to widen the gap between developed and underdeveloped nations. The TPI will be a valuable tool for tracking attitudes in future studies that examine the role of SES.

1.2.4. Expertise

The TPI can be useful in the design of adaptive interfaces since different types of users are likely to have predictably different needs. For example, those with handicaps, both physical and mental, face different challenges and require different solutions. Even within normal ranges of ability, there are variations in attitudes that affect performance. Knowledge of user attitudes will be useful to designers who will be able to customize the interface to accommodate diverse but internally homogeneous groups of users.

2. Study 1

The intent was to build on our preliminary version of the TPI (DeYoung & Spence, 2004), by creating and refining items for measuring attitudes to IT, examining their factor structure, and investigating potential associations between the emergent factors and variables that have, in the past, been associated with responses to computers. These variables include gender, age, experience with IT, and the various applications and uses of IT. DeYoung and Spence (2004) originally created a pool of 49 items designed to cover a range of attitudes toward computers and the internet and administered this set of items to a large sample ($N = 318$). Factor analysis was used to extract seven interpretable factors: Interest, Approval, Confidence, Anxiety, Internet Transactions, Entertainment, and Complex Design Preference. The last three of these factors were small, but we intentionally erred on the side of over-extraction so as to avoid missing any potentially important factors. The present study used a scale composed of 95 items (the original 49 supplemented by 46 new items), with the additional items added to equalize (approximately) the number of items representing each factor. For the final version of the TPI, it is important to ensure that the factors included are reliable and replicable. This two-stage process provided a rigorous approach to identification of the major dimensions underlying attitudes toward IT.

2.1. Method

2.1.1. Participants

The 95 items were rated by 394 participants (134 male, 258 female, 2 no gender reported). Participants were volunteer undergraduate students at the University of Toronto ranging in age from 17 to 61 with a mean of 20 years. Although the majority of respondents were first or second year undergraduates, all undergraduate years of study were represented, as were students from M.A., M.Sc., and Ph.D. programs. Most students were enrolled in the Faculty of Arts and Science, with 25 different programs of study reported. Over 88% had English as their first language and the majority of the remainder had a Chinese or an Indian language as their mother tongue. Less than one percent had Arabic or a European language as a first language.

We recruited an additional 27 student volunteers (11 male, 16 female) who participated for $10 compensation in an experiment designed to illustrate the utility of the TPI in a practical HCI task.

2.1.2. Measures

The original 49 TPI items were supplemented by 46 new items that were created by a process similar to that described by DeYoung and Spence (2004). Several HCI researchers generated items representative of the seven factors (described above) identified in the initial development of the TPI. The process ensured that a roughly equal number of items was included for each factor. Increasing the numbers of items for the smaller factors allowed us to investigate the reliability of these factors, which were more likely to be replicated with a larger number of relevant items included.

In addition to the TPI, participants completed the Big Five Inventory (BFI), a 44-item personality instrument (John & Srivastava, 1999), the Wonderlic® Personnel Test, a short test of cognitive ability that correlates highly with full scale IQ measures (Wonderlic, 2002), and a simple questionnaire regarding their use of IT.

2.1.3. Procedures

Participants ($N = 394$) responded to the TPI items using a 5-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5). They also completed the BFI, Wonderlic®, and IT usage questionnaires. The additional volunteers ($N = 27$) completed the TPI and participated in a small web searching experiment.

2.1.4. Data analysis

Factor and reliability analyses were used to examine the factor structure and identify the most reliable items marking each factor. Regression analysis was used in the HCI experiment.

2.2. Results

2.2.1. Factor structure

A principal components analysis with varimax rotation was performed on the responses of the 367 participants who responded to *every* item (27 participants did not respond to all items). The first 10 eigenvalues were 23.4, 6.0, 4.4, 3.0, 2.6, 2.2, 1.9, 1.8, 1.7, 1.6, and a scree plot suggested that at most four factors should be extracted. The first three factors encompassed 85 of the 95 items, and were easily interpretable as *Confidence* (vs. Anxiety), *Approval*, and *Interest*. These three factors, accounting for almost 40% of total variance, replicated the three largest factors found by DeYoung and Spence (2004), with Confidence and Anxiety collapsed as opposite poles of the same factor (similar to the findings of Whitley, 1996a). A fourth factor, which we named *Internet Transactions*, also replicated our previous results, but this factor was much smaller, with only 5 items loading above .4. This smaller, but replicable, factor representing enthusiasm for making commercial transactions on the internet was only moderately correlated with *Confidence*, *Approval*, and *Interest*. This factor might be useful in some applications (e.g. marketing research). The other two small factors found in our previous study (DeYoung & Spence, 2004) were not replicated when additional factors beyond four were extracted. We therefore concluded that they are not reliable distinct dimensions of attitudes toward IT. The large first eigenvalue evident in the scree plot suggested that that a total TPI score, across factors, could be taken to represent a generally positive or negative attitude toward IT.

2.2.2. Item selection

For each of the three major factors, ten of the most strongly loading items were chosen for the final subscales, taking care to include a balance of positively and negatively keyed items. Subscale scores were calculated by averaging responses, after reversing negatively keyed items. Additionally, a total TPI score was calculated by averaging the *Confidence*, *Approval*, and *Interest* scores. We decided not to include items that loaded highly on the *Internet Transactions* factor in the final scale (reproduced in the Appendix A), but these items are available to any interested researcher upon request.

2.2.3. Reliability

The Cronbach α coefficients and inter-item correlations for the first four subscales and the TPI total score are shown in Tables 1 and 2.

2.2.4. Test-retest reliability

$N = 47$ participants were retested after intervals ranging from 9 months to 14 months. Data from 5 participants were discarded because of failure to complete all items or ambiguous responses after attempts to change responses. The test–retest correlations for the remaining $N = 42$ participants are shown in Table 3.

2.2.5. Personality and IQ

The correlations between the TPI subscales, the TPI total score, the Big Five Inventory subscales, and the Wonderlic® Personnel Test are shown in Table 4.

2.2.6. Gender differences

Our finding of gender differences (see Fig. 1) for all factors of the TPI except *Approval* replicates DeYoung and Spence (2004) and is consistent with Whitley (1996a).

Table 1
Reliability coefficients.

Factor	Cronbach's α	Mean inter-item correlation
Confidence	.92	.53
Approval	.89	.45
Interest	.90	.47
Internet transactions	.74	.34
TPI total	.94	.35

Table 2
Means, SDs, and Intercorrelations of TPI Scales.

	Confidence	Approval	Interest	Transactions	M (SD)
Confidence	–				3.60 (.84)
Approval	.57**	–			4.02 (.72)
Interest	.54**	.49**	–		2.83 (.83)
Transactions	.26**	.13*	.27**	–	2.47 (.94)
TPI total	.86**	.81**	.82**	.27**	3.46 (.63)

* $p < .05$ (2-tailed).
** $p < .01$ (2-tailed).

Table 3
Test–retest correlations.

Scale	Correlation
Confidence	.84**
Approval	.78**
Interest	.91**
TPI total	.90**

** $p < .01$ (2-tailed).

Table 4
Correlations with the BFI and Wonderlic® Intelligence Scales.

	Confidence	Approval	Interest	Transactions	Total TPI
Extraversion	.08	.10*	−.04	−.02	.05
Agreeableness	.13**	.18**	.12*	−.11*	.17**
Conscientiousness	.10*	.15**	.04	−.02	.10*
Neuroticism	−.20**	.03	−.15**	−.13	−.14*
Openness/intellect	.21**	.16**	.16**	.11*	.25**
Wonderlic®	.03	−.01	−.08	.15*	−.01

* $p < .05$ (2-tailed).
** $p < .01$ (2-tailed).

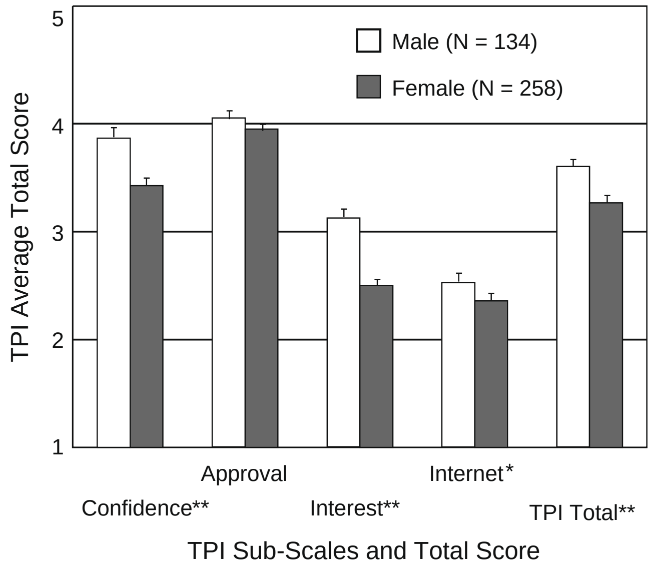

Fig. 1. Average scores on four of the TPI sub-scales (*Confidence*, *Approval*, *Interest*, and *Internet Transactions*) for males and females. The average TPI score is also shown. There is a significant gender difference (** denotes $p < .01$ and * denotes $p < .05$) on all sub-scales and the total TPI score, with the exception of *Approval* where no difference was found.

2.2.7. User IT behavior

Correlations with IT usage (see Table 5) replicate our previous findings (DeYoung & Spence, 2004, p. 61).

2.2.8. Web search

We used an internet web-searching task to illustrate the utility of the TPI in HCI studies. An additional 27 student volunteers (11 males, 16 females) from the University of Toronto participated for $10 compensation. Participants viewed the *Sympatico* web site home page (http://sympatico.msn.ca) and were given instructions to search for nine different items within the *Sympatico* site. Sample

Table 5
Correlations with time spent on work and personal activities.

	Confidence	Approval	Interest	Transactions	Total TPI
Total computer time	.24**	.25**	.31**	.22**	.33**
Internet time	.21**	.27**	.27**	.20**	.30**
Personal computer time	.23**	.27**	.28**	.18*	.32**
Work computer time	.09	.00	.13*	.11	.09
Cell phone time	.01	.08	.01	.02	.04

Note: Each row variable represents hours of use per week, transformed logarithmically to reduce skewness. Total = Total TPI score.
* $p < .05$ (2-tailed).
** $p < .01$ (2-tailed).

search items included: "Find the page that lists the dial-up numbers across Canada"; "Find the page that discusses women in business"; "Locate the latest Lotto 6/49 numbers". Participants were told to be efficient and to minimize the number of mouse clicks in their search for the target (Fraser & Locatis, 2001; Gwizdka and Spence, 2007; Schrepp, 2006). Each search was started from the home page. The number of mouse clicks to find the target was recorded for each question and each participant.

We used regression to determine whether the TPI data could predict the number of mouse clicks (Clicks) required to find answers to the search questions. Both *Confidence* ($r = -.37$, $p = .06$) and *Internet Transactions* ($r = .47$, $p = .03$) were found to be good predictors of Clicks but with opposite signs: Clicks = −11.1 ∗*Confidence* + .13.8 ∗*Internet Transactions* ($R^2 = .58$, $p < .01$; $p < .05$ for both variables in the regression).

2.3. Discussion

Building on a preliminary study (DeYoung & Spence, 2004), we developed the Technology Profile Inventory (TPI) to assess attitudes toward IT. Three large factors, consistent with our preliminary study and with the previous literature, appear to account for most of the variance in attitudes toward IT. The TPI provides a reliable and valid measure of these factors, *Confidence* (vs. *anxiety*), *Approval*, and *Interest.*

All TPI scales were positively associated with computer and internet usage (providing convergent validation), but not with cell phone usage, a related technology not explicitly referenced by any TPI items (providing discriminant validation). TPI scores were more highly correlated with personal computer use than work-related computer use, perhaps reflecting the fact that the use of a computer (and specific software) for work is usually mandatory while personal preferences can be exercised during leisure time. This pattern is consistent with previous findings that computer attitudes correlate positively with computer use and experience (Bozionelos, 2001; Levine and Donitsa-Schmidt, 1998; Smith, Caputi, Crittenden, Jayasuriya, & Rawstorne, 1999). The causal relation between attitudes and experience is likely to run in both directions; experience may engender more positive attitudes, but positive attitudes may encourage additional experience through increased use.

The gender differences which we observed are probably mostly cultural in origin. The early socialization and play activities of boys and girls are generally quite different (Terlecki & Newcombe, 2005; Halpern et al., 2007) and probably result in differential familiarity with IT-related activities. Additionally, women may not be given as much support as men for developing confidence in using IT, or interest in it, despite equal approval of its functions and uses.

The associations of the TPI with the Big Five personality traits and cognitive ability are generally weak, indicating that attitudes toward IT are relatively independent of the broad fundamental traits that govern people's behavior across many other situations. This independence may be attributable both to the specificity of the attitudes relevant to IT and to the differences between the IT setting and the environment in which the basic organization of human personality evolved. The weak associations between personality and TPI scores probably reflects the fact that attitudes are more malleable than personality traits which are more deeply seated. Indeed, in our second study (reported below), we show that attitudes toward IT can be changed in a relatively short space of time.

Two of the strongest associations observed were between Neuroticism and Confidence and between Openness/Intellect and total TPI score. Given that Neuroticism reflects the general predisposition to experience negative emotions (John & Srivastava, 1999), including anxiety, it is not surprising that higher levels of Neuroticism are associated with significantly less confidence and more anxiety about using IT. Openness/Intellect reflects the tendency to be cognitively flexible and exploratory and to have intellectual and artistic interests (DeYoung, Peterson, & Higgins, 2005; John & Srivastava, 1999). People high in Openness/Intellect, therefore, may be more curious about IT, more open to embracing new technologies and their potential benefits, and better able to adapt cognitively to the complexities of the IT environment, leading to greater confidence, approval, and interest in IT.

The internet web search study found that TPI factor scores could predict the number of clicks made by searchers. People who scored higher in *Confidence* tended to make fewer clicks, while people scoring higher in *Internet Transactions* tended to make more clicks. This result indicates the potential utility of separating the TPI into its subscales. People who are high in *Confidence* may be more likely to navigate toward their goals quickly when searching the internet, whereas those high in *Internet Transactions* may be more likely to explore more of the links available, perhaps reflecting a desire to examine the available options more thoroughly. Although this demonstration used a very small sample, the TPI scores provide an additional useful perspective on web search behaviour, a very common HCI task.

3. Study 2

Our laboratory has recently demonstrated (Feng, Spence, & Pratt, 2007) that certain gender differences in low-level cognitive functions can be reduced or eliminated by training using an action video game. Abilities in selective attention and spatial cognition were the principal focus of the experiments, but, in addition, all participants completed the TPI. The purpose of administering the TPI was to determine whether (1) existing attitudes to IT might differ in distinct sub-groups, and (2) whether attitudes to IT would be modified in parallel with changes in cognitive functioning.

3.1. Method

3.1.1. Participants

In experiment 1 of Feng et al. (2007), 48 student volunteers (age: 19–30 years) from the University of Toronto participated for either for a course credit or $10/h monetary compensation. The participants in the $2 \times 2 \times 2$ design (with $n = 6$ participants per cell) were balanced with respect to gender (24 males vs. 24 females), video-gaming experience (24 players vs. 24 non-players), and also field of study (24 students from Arts and Humanities vs. 24 students from Science and Engineering).

In experiment 2 of Feng et al. (2007), 20 additional undergraduate participants were recruited. Six males and 14 females (age: 18–32 years) participated for $50 compensation. All participants reported having had no gaming experience in the preceding four years.

3.1.2. Measures and procedures

In experiment 1, we used our own computerized implementation of an attentional visual field (AVF) task to measure selective attention (Ball & Roenker, 1998). Participants very briefly viewed a display which consisted of one target and a number of distractors located at different eccentricities and in different directions. They then indicated the direction in which the target had appeared. This well established paradigm not only assesses the ability to detect, localize and identify a target, but also gives a picture of the spatial distribution of attentional resources.

In experiment 2, in addition to the AVF task, participants also completed a Mental Rotation Task (MRT) (Peters & Battista, 2008; Vandenberg & Kuse, 1978). This task reveals the most salient and reliable gender difference in spatial cognition. Participants were asked to compare the drawing of an object in one orientation with four other objects in different orientations. Then they had to select the two objects which were identical to the first one.

The experiment used a pre-test – training – post-test paradigm. Participants were randomly divided into an experimental group and a control group, matched as closely as possible on gender and performance on the pre-test tasks. During training, the experimental group played an action video game, while the control group was trained using a non-action video game. Each group had ten hours of training in sessions of one to two hours within a maximum duration of four weeks. A post-test with the two cognitive tasks and the TPI was administered at a later, separate time after a participant had completed the training.

3.2. Results

3.2.1. Cognitive tests

Our focus in this paper is on the TPI results and we refer the reader to Feng et al. (2007) for a more detailed report of the results of the cognitive testing. We give only a brief summary here. In experiment 1, males outperformed females on the AVF task. players made fewer errors than non-players, and students from Science and Engineering performed better than students from Arts and Humanities. In experiment 2, participants who had trained with the action video game made significantly fewer errors on the AVF task whereas no differences between pre-test and post-test performance occurred in control group that had been trained with the non action video game. Similar results were obtained on the MRT test. Thus, playing an action video game enhances capacity in selective attention and spatial cognition. Furthermore, while both males and females in the experimental group improved after training, the females benefited more than the males. After playing the action video game for only 10 h, the gender differences on the AVF task were largely reduced or even eliminated.

3.2.2. TPI scores

A summary of the TPI total score means for the two experiments is shown in Fig. 2. In experiment 1, we found that (1) males hold more positive attitudes toward IT than females; (2) Video game players hold more positive attitudes toward IT than non-players; and (3) individuals with more positive attitudes toward IT are more likely to choose fields related to science and technology for their educations and careers. In experiment 2, the experimental group showed positive changes in total TPI score from pre-test to post-test whereas the control group did not ($F = 6.28$, $p < .02$, $\eta_p^2 = .26$). The experimental group showed change in the overall *TPI* score, $t(9) = 3.87$, $p = .004$, in *Confidence*, $t(9) = 3.28$, $p = .01$, in *Approval*, $t(9) = 2.69$, $p = .03$, and also in *Interest*, $t(9) = 2.42$, $p = .04$. However, the control group showed no significant changes on any of the TPI factors from pre-test to post-test.

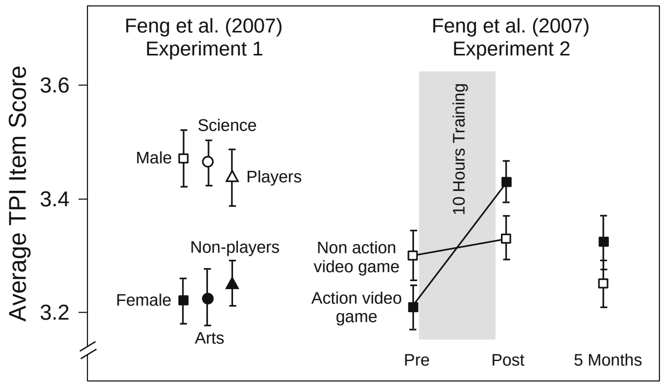

Fig. 2. The left panel shows that total TPI scores for males, Science students, and video game players are higher, on average, than for females, Arts students, and non-players. The data for experiment 2 show that training with an action video game for ten hours is associated with an increase in the total TPI score, while training with a non-action game is not. However, after five months, the total TPI score in the experimental group has returned to pre-training levels. The error bars represent one standard error on either side of the mean.

If we compute the percentage changes by considering the ratio of the post-test scores to the pre-test scores, the experimental group improved their *TPI* total score by about +8.8% (*Confidence* +8.5%; *Approval* +7.5%; *Interest* +10.9%). In contrast, the control group remained quite stable in total *TPI* score (+0.4%), although there were subtle fluctuations in the sub-scales: *Confidence* −1.2%; *Approval* −1.3%; *Interest* +4.7%. In the experimental group, females significantly improved their attitudes toward IT, whereas no change for males was observed. Significant positive changes for females were observed: *TPI*, $t(6) = -4.12$, $p = .006$; *Confidence*, $t(6) = -3.29$, $p = .017$; *Interest*, $t(6) = -4.58$, $p = .004$. However, in *Approval*, the change for females was not significant, $t(6) = -1.91$, $p = .105$. In the scores for males, none of the changes after training were significant. In the control group, no significant attitude change for either males or females was found.

We had not originally planned a follow-up testing session; however, we were subsequently able to contact and re-test all 20 participants after an average interval of about five months (16–24 weeks). Interestingly, although the cognitive changes were maintained (Feng et al., 2007), the attitudinal changes were not. As can be seen in Fig. 2, the TPI scores for both the experimental and control group have dropped back into the range of the pre-training scores.

3.2.3. Discussion

Gender differences were observed in experiment 1, with males being generally more positive in their attitudes toward IT (left panel of Fig. 2). This finding is compatible with DeYoung and Spence (2004) and Study 1 above. The observed difference between players and non-players is consistent with findings that video gaming experience can increase an individual's willingness to engage with high technology (Bandura, 1997; Canada & Brusca, 1991; Greenfield et al., 1996). Although we are unable to point to previous studies that have investigated differences in attitudes between students from different fields of study, the difference between Arts and Humanities students and Science and Engineering students makes intuitive sense. Because confidence, interest, and approval are important considerations when an individual makes educational or career choices, it is understandable that students from Science and Engineering hold a generally more positive attitude toward IT.

In experiment 2, we observed the same kinds of changes in attitudes as we observed in performance on the attentional and spatial cognition tasks. The TPI scores of the group that had played action video games were significantly more positive after training while no significant change was observed in those subjects who had trained with a non-action video game. An individual's attitude toward IT seems to become more positive after training using action video games. It is remarkable that only ten hours of training with an action video game can alter attitudes as well as fundamental cognitive capacities. However, during the five months that participants did not play video games (with only two exceptions out of 20 participants) the improvement in attitudes to IT in the experimental group was not maintained, perhaps suggesting that continued exposure to this type of game may be necessary to maintain or enhance the positive view of IT. However, we note that the positive cognitive benefits in spatial cognition were maintained (Feng et al., 2007), suggesting that fundamental neural changes had taken place during the training.

4. General discussion

The TPI provides a comprehensive and up-to-date instrument for measuring attitudes toward computers and the internet. The two studies presented here demonstrate the relevance of the TPI to research in HCI, including gender differences, individual differences in the use of IT, and differences in performance on IT tasks. Measuring attitudes can provide a valuable additional perspective in HCI studies where the principal focus may be on other psychological variables. The TPI can help to provide useful insights even when the sample sizes are relatively small, as in our illustrations. Where attitudes to IT constitute the major focus of interest, sample sizes will likely be much larger and, since it possesses good psychometric properties, the TPI should be a useful tool in such studies.

To be truly useful, an instrument such as the TPI must be continuously updated. The pace of change in IT and changes in attitudes on the part of the users of IT can be dramatic. Our future plans include the online collection of data from large numbers of respondents and a regular revision of the TPI based on these data.

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Appendix A. The technology profile inventory

The statements below are about attitudes toward computers and the internet. Using the scale below as a guide, write a number on the line in front of each statement to indicate the extent to which you agree or disagree with each statement. *Be as honest and as accurate as possible.* Use the following scale:

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5
Strongly Disagree — Neutral — Strongly Agree

__1. I do not have trouble learning how to do things with computers.
__2. I would be interested in finding entertainment on the internet.
__3. I would enjoy reading magazines or books about computers.
__4. Computers make me nervous, anxious, or tense.
__5. I think almost everyone could benefit from using the internet.
__6. I like to use new software.
__7. I find dealing with computers to be stressful.
__8. I frequently use the internet to look up things that interest me.
__9. I would like to see more shows about computers on TV.
__10. I have a lot of confidence in my ability to accomplish things with computers and the internet.
__11. I don't like to use computers.
__12. Learning about computers and the internet is boring.
__13. I find the internet confusing and disorienting.
__14. Computers can be a great source of entertainment.
__15. Learning about computers can be fun even when it isn't useful.
__16. I rarely find computers frustrating.
__17. I do not consider owning a computer to be a necessity.
__18. I would be interested to learn about new technology for computers or the internet.
__19. I wish using computers wasn't so difficult.
__20. Working with computers and the internet can be enjoyable and stimulating.
__21. I don't care to know about how computers and the internet work.
__22. I often feel overwhelmed by the complexity of computers.
__23. I do not find surfing the internet relaxing and pleasurable.
__24. I don't want to know more about computers than I have to.
__25. I often feel I need help when using computers.
__26. I don't like to use the internet.
__27. I like to think up new ways of doing things with computers.
__28. I feel at ease using computers and the internet.
__29. Computers are useful educational tools.
__30. I'm not interested when people discuss computers.

Scoring key

Confidence (*vs. Anxiety*): 1, 4R, 7R, 10, 13R, 16, 19R, 22R, 25R, 28
Approval: 2, 5, 8, 11R, 14, 17R, 20, 23R, 26R, 29
Interest: 3, 6, 9, 12R, 15, 18, 21R, 24R, 27, 30R

Scoring

Confidence, *Approval*, and *Interest*: Compute the total score of all items listed for each factor in the key, after making the reversals indicated by "R" (1 = 5, 2 = 4, 3 = 3, 4 = 2, 5 = 1).

TPI Total Score (indicating general positive vs. negative attitude toward IT): Compute the total of all three factor scores.

A formatted Adobe Acrobat PDF file of the TPI (suitable for printing and administration in paper form) is available from the corresponding author. The items that comprise the *Internet Transactions* sub-scale are also available on request.

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