IMPLICIT THEORIES OF TECHNOLOGY: IDENTIFICATION AND IMPLICATIONS FOR PERFORMANCE

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What makes someone "good with technology," or else "technologically illiterate"? The study of implicit theories has previously demonstrated that people develop ideas about the malleability of their own abilities in a number of domains, including intelligence, athletics, gaming and using technology. Some think of their abilities as fixed and unchangeable (entity theorists), while others think of them as adaptable through work and/or experience (incremental theorists). These beliefs influence people's goal outcomes. In this study, we examine implicit theories as a possible contributor to people's performance using modern technologies. We use an adapted instrument to measure implicit theories of technology, followed by an ecologically valid technological task. People with incremental theories showed better performance than those with entity theories. We discuss implications of this research for practitioners, as well as avenues for future research.

Why do some people, when presented with a new technology, learn to use it quickly and easily, while others, presented with the same technology, seem frustrated and discouraged by it? Previous research in human factors has generally focused on qualities of the technologies themselves. For example, usability studies focus on adapting interface controls to better fit the needs and cognitive requirements of users. Other research has focused on efficiently providing training on the interface. However, these strategies do not entirely solve the problems that users face; by some estimates, only about 53% of them (Czaja, Charness, Fisk, Hertzog, Nair, & Rogers, 2006).

Relatively little concern has been given to the psychological characteristics of the users themselves, with a few notable exceptions. Human factors research has long given consideration to the effect of stress on performance (Broadbent, 1971). Davis's (1989) Technology Acceptance Model and its extensions (e.g. the Unified Theory of Acceptance and Use of Technology [Venkatesh, Morris, Davis, & Davis, 2003]) examined users' perceptions of technologies, especially usefulness and ease-of-use, to predict motivations to use them and subsequent usage. Recently, Szalma (2014) integrated motivation psychology into a model of human-computer interaction. However, some have noted that human factors researchers largely tend to consider the human operator a "black box," preferring not to examine underlying psychological factors (Szalma, 2009).

Implicit Theories

One psychological characteristic that may help to explain differences among technology users is implicit theories. Implicit theories are lay beliefs about human attributes, their stability, and their impact on events (Ross, 1989). These theories can be broadly classified into two main categories: *entity* or *incremental theories* (Dweck & Leggett, 1988). Entity theories are based on the belief that the attribute in question is fixed and cannot be changed, whereas incremental theories suggest the attribute is malleable and may be developed (for example, with hard work). Researchers have identified implicit theories about intelligence, athletics (Kasimatis, Miller, & Marcussen, 1996), and weight management (Burnette, 2010), among many others. Furthermore, implicit theories can be used to predict behavioral outcomes. For example, students with an incremental theory of intelligence had better academic outcomes than students with an entity theory (Dweck, 1996).

Could people have implicit theories about their abilities to use technologies? Prior research has primarily focused on similar constructs such as computer self-efficacy. In one study, Martocchio (1994) induced implicit theories of a similar related construct, the ability to learn to use novel technologies, and found that it affected outcomes after a period of training. He found the effect to be relatively small compared to age and computer self-efficacy. However, the outcome measure, declarative knowledge about computers, was perhaps not a true performance measure. Other studies in related domains have shown an effect of implicit theories on performance. For example, people with an entity theory of gaming performed worse on a game than people with incremental theories (Lee, Heeter, Magerko, & Medler, 2012).

Present Study and Predictions

Are implicit theories related to the relatively poor performance of some users with modern technologies? To address this question, we adapted an instrument used to measure implicit theories in other domains to measure implicit theories of technology. After completing the instrument, participants performed 65 trials of an ecologically valid technological task: finding and clicking elements of web interfaces. In line with previous work, we expect to observe both entity and incremental theories naturally occurring within the sample population (H1). Furthermore, we predict that incremental theorists will perform better on the task than entity theorists in terms of time (i.e. faster), accuracy, and number of clicks per trial (H2).

METHOD

Participants

We recruited a total of 214 participants online from a pool of students taking an introductory psychology course at a large southeastern university, as well as Amazon Mechanical Turk. Student participants were given course credit, while participants from Amazon Mechanical Turk were compensated with approximately 60¢ for their time. Five participants reported having vision deficiencies and were removed. A total of 57 additional participants were removed from analyses for failing to follow important instructions. As examples, 29 were removed for leaving the online experiment early, and another 5 were removed for using a device that was incompatible with the experiment software. Ultimately, 152 participants (aged 18-68, *M*=24.81 years, *SD*=10.98; 78 males) were included in analyses. Of those that remained, 121 were from Amazon Mechanical Turk. Most participants (79.73%) reported high school or some college as their highest level of education achieved.

Materials

Implicit theory. Implicit theories were measured using a 3-item instrument adapted from Dweck & Leggett (1989). The items included, "Your ability to understand new technologies is something about you that you can't change very much," "You have a basic ability to understand new technology and you can't really do much to change it," and "People can learn how to use new technology, but you can't really change whether or not you understand new technologies." Participants rated the degree to which they agreed or disagreed with these statements using a 7-point Likert scale ranging from "Strongly disagree" to "Strongly agree."

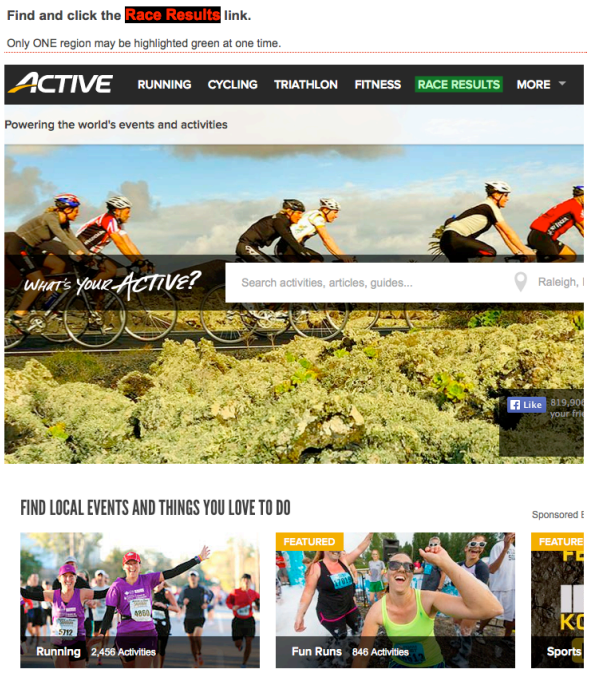

Figure 1. Example trial

Technological task. Participants completed one practice trial and 65 randomized trials of a technological task. In each trial, the participant was presented with a screenshot of a website and an instruction to locate and click a certain element on that website (e.g. the search bar; see Figure 1). The trials included 13 different websites, and 5 unique elements per website. Data from the practice trial were not included in analyses.

Measures

The web survey software recorded a number of performance measures automatically during the technological task. Task accuracy (DV #1) was determined by whether or not the participant clicked the correct element. Task time (DV #2) was measured as the time in seconds that the participant took to make their final click on each trial. Furthermore, the number of clicks (DV #3) the participant made on each trial was measured.

RESULTS

Implicit theories. Participant responses to the 3-item instrument showed a moderately strong internal reliability, Cronbach's α = .88. Using a hierarchical cluster analysis on instrument responses, participants were categorized into two groups, reflecting either an entity or incremental theory of technology use (H1). More participants had an incremental theory (133 participants, or 86.92%) than an entity theory (20 participants, or 13.07%).

Performance measures. To determine the effect of implicit theory on performance (H2), we conducted a repeated measures Multivariate Analysis of Covariance (MANCOVA), with a multivariate performance factor (time, accuracy, and clicks) using 65 trials per participant, and implicit theories, age, education, gender, and participant population (i.e. students or Mechanical Turk) as covariates. Implicit theories had a significant effect on performance, F (3, 140)=6.66, p < .001, partial η^2=.13. Participants with incremental theories performed faster on average (*M*=10.04s per trial) than participants with entity theories (*M*=11.51s). Furthermore, participants with incremental theories were more accurate on average (*M*=98.01% overall) than participants with entity theories (*M*=86.25%). Finally, participants with incremental theories completed trials in fewer clicks on average (*M*=1.20 clicks per trial) than participants with entity theories (*M*=1.26 clicks).

DISCUSSION

In the present study, we assessed participants' implicit theories of using technology, and observed how participants with different implicit theories performed on an everyday technological task. We found evidence that participants held the predicted theories about the ability to use technology, and that these theories may have an effect on performance. Participants with an incremental theory of

technology use showed better performance on all three of the performance measures taken. They were, on average, faster, more accurate, and required fewer clicks, than participants with entity theories. Furthermore, the effect of implicit theory on performance was significant even with age and education as covariates, which have been previously shown to be important predictors of performance (Czaja, et al., 2006).

Limitations

An important limitation to the present study is that all participants were recruited online, many of whom were removed from analyses, possibly biasing the sample. We observed a very large proportion of incremental theorists in comparison to entity theorists. This may reflect a cohort effect, i.e., younger people may be more likely to have an incremental theory of technology use than older adults.

This study also uses a relatively simple technological task with which members of the participant pool are ostensibly already somewhat familiar. It is possible that the effect of implicit theory would be different if an unfamilar task was used instead. Future studies could replicate the results of this study by using one of a variety of other tasks or performance measures. For example, participants could attempt to find problems in an interface, or researchers could measure time needed to learn a novel interface.

Future Research

The present research provides a basis for researchers and practitioners to begin including measures of implicit theories in usability studies, for example, in order to better understand their target user population, or to reduce the amount of error variance in results from testing. More importantly, while implicit theories are often thought of as dispositional, stable, or trait-like (Dweck, 2008), some studies have at least temporarily changed them with priming (Burnette, 2010) or longer-term longitudinal interventions (Blackwell, Trzesniewski, & Dweck, 2007; Burnette & Finkel, 2012). Therefore, rather than naturalistically asssessing them, future studies should manipulate implicit theories. If users' implicit theories can be altered and subsequent performance improved, this could be a boon to users and researchers alike.

One common focus of human factors research over the last 25 years has been aging and technology usage. It is generally accepted that the aging "baby boom" cohort will significantly increase the proportion of retired persons in American society within the next 20 years. As people age, changes in cognition, motor control, and perception can create difficulties using technologies (Fisk, 2009). As smart technologies in appliances, communications, and entertainment become more widespread, and new technologies continue to be developed and introduced into the marketplace, it is important that any difficulties in usage faced by this population be addressed and mitigated to enhance and maintain their quality of life (Czaja & Schulz, 2006). Indeed, even today it is difficult to avoid using technology in everyday tasks, such as checking in at an airport kiosk, making withdrawals from ATMs, and purchasing groceries via self-check out machines (Fisk, 2009). In the present study, we were unable to determine age-related differences in implicit theories, possibly due to the online sample. Future research should study participants across a larger range of ages. It is possible that interventions designed to change older adults' implicit theories could make a great difference in their everyday technology interactions.

REFERENCES

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*(1), 246-263.

Broadbent, D. A. (1971). *Decision and stress*. London, UK: Academic Press.

Burnette, J. L. (2010). Implicit theories of body weight: Entity beliefs can weigh you down. *Personality and Social Psychology Bulletin, 36*(3), 410-422.

Burnette, J. L., & Finkel, E. J. (2012). Buffering against weight gain following dieting setbacks: An implicit theory intervention. *Journal of Experimental Social Psychology, 48*(3), 721-725.

Czaja, S. J., & Schulz, R. (2006). Innovations in technology and aging: Introduction. *Generations (San Francisco, Calif.) [H.W. Wilson - SSA], 30*(2), 6.

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. (2006). Factors predicting the use of technology: Findings from the center for research and education on aging and technology enhancement (CREATE). *Psychology and Aging, 21*(2), 333-352.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340.

Dweck, C. S. (1996). Capturing the dynamic nature of personality. *Journal of Research in Personality, 30*(3), 348-362.

Dweck, C. S. (2008). Can personality be changed?: The role of beliefs in personality and change. *Current Directions in Psychological Science, 17*(6), 391-394.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*(2), 256-273.

Fisk, A. D. (2009). *Designing for older adults: Principles and creative human factors approaches*. Boca Raton, FL: CRC Press.

Kasimatis, M., Miller, M., & Marcussen, L. (1996). The effects of implicit theories on exercise motivation. *Journal of Research in Personality, 30*(4), 510-516.

Lee, Y., Heeter, C., Magerko, B., & Medler, B. (2012). Gaming mindsets: Implicit theories in serious game learning. *Cyberpsychology, Behavior and Social Networking, 15*(4), 19-194.

Martocchio, J. J. (1994). Effects of conceptions of ability on anxiety, self-efficacy, and learning in training. *Journal of Applied Psychology*, *79*(6), 819.

Ross, M. (1989). Relation of implicit theories to the construction of personal histories. *Psychological Review, 96*(2), 341-357.

Schroeders, U., & Wilhelm, O. (2011). Computer usage questionnaire: Structure, correlates, and gender differences. *Computers in Human Behavior, 27*(2), 899-904.

Szalma, J. L. (2009). Individual differences in human–technology interaction: Incorporating variation in human characteristics into human factors and ergonomics research and design. *Theoretical Issues in Ergonomics Science*,*10*(5), 381-397.

Szalma, J. L. (2014). On the application of motivation theory to human factors/ergonomics: Motivational design principles for human–technology interaction. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *56*(8), 1453-1471.

Venkatesh, V., Morris, M. G., Davis, F. D., & Davis, G. B. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.