PROJECT SUMMARY

Overview Summary

Imminent demographic changes, especially the impending retirement of the "baby boom" generation, and continual technological advances are soon to pose challenges for millions of older adults seeking to maintain and improve their quality of life. Managing the healthcare of a larger proportion of aging adults will become a concern of particular importance. Providers are already seeking ways to offset workload and resources with pervasive, in-home technologies, and are likely to expand these efforts. The health of older adults, who face unique age-related challenges in learning and using novel technologies, will thus increasingly depend upon their ability to effectively navigate technological tasks. We propose a mindset intervention intended to shift older adults' beliefs about their own ability to do that, especially, to suggest that having consistent success with technology is a developable skill. We will test how mindsets influence the self-regulatory processes people choose to meet technology-related goals, as well as the likelihood they will adopt a system, and their perceptions of that system.

Intellectual Merit

Mindsets, or implicit theories, as a construct, have been extensively studied in a variety of domains, especially intelligence, for decades. Study of mindsets related to a general technology ability in particular is less mature and comparatively recent. Although interventions have been attempted successfully in multiple domains, whether or not an intervention in this field will be effective remains to be studied. This research, furthermore, integrates mindsets with comparatively isolated subfields. Technology adoption, for example, has been deeply studied in institutional contexts. Researchers have developed sophisticated models of many of the relevant characteristics of users and the systems themselves that will lead to successful adoption more broadly. The self-regulatory processes associated with mindsets may provide a richer theoretical understanding of these characteristics. Empirical support for this relationship is still limited. The proposed study will also integrate mindsets into usability research often cited by practitioners. Should we observe the expected results, both the scholarly community and professionals will have a better understanding of the relationships of mindsets, adoption, and usability.

Broader Impacts

Directly applying the results of the proposed research to the adoption of healthcare technologies by older adults would mitigate the effects of a critical issue facing American society in the immediate future, and would improve the health and quality of life of older adults for generations to come. Although a blood pressure monitoring app will be used, we may expect the conclusions of the proposed study to generalize across medical technologies. The healthcare industry's initiative to increasingly provide services through in-home technologies, if effective, would significantly reduce the financial burden to do so, while simultaneously strengthening the medical technology industry as demand grows. We will work to disseminate the results of this research to professionals within both of these communities to make its benefits more widely available. Considering previous research, we would furthermore expect that these results would generalize across technologies and user demographics. We would thus strive also to publish this work in academic journals and the popular press. This work would also contribute towards the next generation of STEM researchers, as it fulfills part of the primary investigator's doctoral requirements.

PROJECT DESCRIPTION

Introduction

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. This unprecedented demographic shift is expected to profoundly change many aspects of daily life and sectors of our economy, especially the technology and healthcare industries.

The technology industry releases many new devices each year, some of which are considered groundbreaking advances. As people age, however, changes in cognition and perception, as well as physical health and motor control, can create difficulties learning and using these novel devices (Fisk, Rogers, Charness, Czaja, & Sharit, 2009). Learning how to use new products and software takes longer as the time to acquire new skills increases (Strayer & Kramer, 1994). Negative transfer or maladaptive mental models associated with previous systems that were used to accomplish a similar goal may lead to mistakes using newer systems (Barnard, Bradley, Hodgson, & Lloyd, 2013). Decreased visual acuity and hearing ability is the root cause beneath many everyday errors from missed or misinterpreted feedback to misunderstandings or lack of awareness of system status and capabilities (Charness & Boot, 2009; Fisk et al., 2009). Age-related changes in motor control lead to additional slips, or unintended errors (Fisk et al., 2009). These and similar or related influences act independently, and often in combination, to pose special challenges for older users.

In particular, 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 maintain and enhance their quality of life (Czaja & Schulz, 2006). Many of these developments extend into user's lives beyond personal devices adopted by the individual's choice, but are more or less imposed by the organizations and industries with whom users interact. 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-checkout machines (Fisk et al., 2009).

Furthermore, older adults suffer from a greater incidence of health problems and require a disproportionate amount of healthcare resources (Centers for Disease Control and Prevention, 2003). The healthcare industry has begun to more often rely upon advanced means for delivering services and communications, as well as monitoring aging patients at home (Arnrich, Mayora, Bardram, & Tröster, 2010). As providers must serve a larger proportion of older adults, they may seek to use such systems for reasons of economy. However, the quality of service will suffer in tandem with the number of problems older adults face with these new and unfamiliar systems. Such difficulties may be improved, for example, through user-centered design principles, or, when appropriate, sufficient training on the interface; both are common approaches from human factors research. These strategies, however, only partially mitigate the problems—by some estimates, around 53% of them (Czaja, Charness, Fisk, Hertzog, Nair, Rogers, & Sharit, 2006).

Mindsets of Technology Ability

A novel approach that could help to attenuate these difficulties may be an intervention of *mindsets*, which are implicit beliefs about the nature and stability of abilities (Dweck, 1986, 2008). People may, on one end of the mindset spectrum, conceive of an attribute, such as intelligence, as an unchangeable innate quality. This is called a *fixed mindset*. On the other end of the spectrum, one might believe that hard work, with the proper educational resources, can effectively increase one's intelligence. This belief that an attribute is developable is called a *growth mindset*. These beliefs are an important predictor of behavior, especially performance outcomes within that domain. For example, students with a growth mindset of intelligence have showed stronger performance in the classroom than have students with a fixed mindset (Dweck, 1986). These effects are independent of the student's actual intelligence.

Researchers have also sought to identify and understand people's mindsets about technology ability. Whether or not there truly is a technology ability trait veridical to the belief, in popular idiom, people speak of it as something one has or doesn't have, or as something that one might develop through study and practice. One might describe another as "technologically challenged" or "tech savvy," or might otherwise encourage someone to explore a novel device, to make mistakes and learn to use it "by doing." Researchers have observed that people hold implicit beliefs about technology ability (Pybus & Gillan, 2015; Pybus, 2016). People who have a more fixed mindset of technology ability, who consider it innate and therefore less changeable, perform more poorly with devices and are less likely to adopt them when compared with people having a more growth mindset, who believe the ability to be developable by experience and work (Pybus, 2016). This work is not without limitation, and much remains to be understood. In research that has explored the effect of mindsets on technology adoption, for example, only the intentions to adopt have been studied, and not actual usage.

Self-Regulatory Processes

The likelihood that someone will adopt a given technology is thought to be a function of the user's perception of the usefulness and ease of use of the system (Davis, 1989). Personal characteristics, such as technology-related anxiety and self-efficacy, are thought to serve as "anchors" in initial judgments of the ease of use for a system (Venkatesh & Bala, 2008). Those anchors function as the salient initial pieces of information used for decision making identified in the anchoring and adjustment heuristic (Tversky & Kahneman, 1974; Venkatesh & Bala, 2008). These are associated with mindsets of technology ability; for example, people with growth mindsets tend to have less technology-related anxiety (Pybus, 2016).

Furthermore, these characteristics share some overlap with the self-regulatory processes that mindsets influence in other domains. Someone with a growth mindset of an attribute is more likely to set learning-oriented goals within that domain, to operate towards those goals using mastery-oriented strategies, and to more frequently and accurately monitor progress towards those goals (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013). Thus, the setting/operating/monitoring/achieving (SOMA; Burnette et al., 2013) model posits that people's mindsets affect their achievement in that domain primarily through self-regulatory processes oriented towards accomplishing that goal.

Initially, people set goals that are either learning- or performance-oriented. *Learning-oriented goals* are primarily concerned with mastering the task (Ames, 1992). These may be contrasted with the *performance-oriented goals*, which are more often chosen by people with fixed mindsets (Burnette et al., 2013), that focus on achieving a specific or minimal level of performance, or on standing out among others (Ames, 1992). As people operate to carry out the goals they have set, they adopt either helpless- or mastery-oriented strategies (Dweck, 1975, 2000). People with fixed mindsets in a domain are more like to choose *helpless-oriented strategies* that undermine their goals, while people with growth mindsets more often choose *mastery-oriented strategies* to seek alternative paths to their goals in the face of setbacks (Chen, Chen, Lin, Kee, Kuo, & Shui, 2008; Dweck, 2000; Burnette et al., 2013). Finally, people monitor their progress towards achieving their goal in different ways (Carver & Scheier, 1998). Those with fixed mindsets tend to have more *negative emotions* associated with goal monitoring, as they find they have not progressed as much or as quickly as they had hoped (Cury, Da Fonseca, Zahn, & Elliot, 2008). People with growth mindsets are more likely to adopt effective monitoring strategies and to monitor often, such that their *expectations* of achieving a goal tend to be more realistic (Burnette et al., 2013).

To date, research on these relationships has relied only on measurements of those judgments and personal characteristics used to predict technology adoption. Using measures of these related self-regulatory processes would strengthen the evidence for their relationships, and help to converge the two bodies of work.

> **H1.** People primed to have a growth mindset of technology will exhibit *more learning-oriented goals* related to technology, compared with those primed to have a fixed mindset.
> **H2.** People primed to have a growth mindset of technology will exhibit *more mastery-oriented strategies* related to technology, compared with those primed to have a fixed mindset.
> **H3.** People primed to have a growth mindset of technology will exhibit *more realistic expectations* of progress made towards their goals related to technology, compared with those primed to have a fixed mindset.

Perceived Usability

In practice, usability professionals are often interested not only in adoption, but in promoting users' perceived usability of the system. Instruments designed to measure perceived usability, such as the widely-used System Usability Scale (SUS; Brooke, 1996), define the construct as governed by ISO standard 9241 on usable displays, often summarized, "effectiveness, efficiency, and satisfaction" (International Organization for Standardization, 1998). Others, such as the Net Promoter Score (NPS; Reichheld & Covey, 2006), though lacking face validity, are often seen in practice as indirect measures of these qualities or the behaviors (such as recommending a system to others) immediately corresponding to them (Brooke, 2013).

Perceived ease of use (PEOU), one of the two key predictors of adoption, is defined as "the degree to which a person believes that a particular system would be free of effort" (Davis, 1989). On its face, it then represents a subset of usability (Quesenbery, 2001), namely, efficiency, although the two constructs have been treated as distinct but related by others (Zviran, Glezer, & Avni, 2006). Mindsets of technology ability are thought to indirectly influence PEOU by affecting the anchors used in initial judgments of it (Pybus, 2016). As previously discussed, measuring self-regulatory processes may be an effective alternative to traditional measures of those anchors. We would then expect self-regulation to affect PEOU.

Self-regulation would like influence broader perceptions of usability, if only where those perceptions overlap with PEOU. The two constructs are influenced by the user, rather than the system, in other ways as well. Objective usability, operationalized by some quantitative measure of time or errors, makes relatively less of an effect on PEOU than do the anchors (Venkatesh & Bala, 2008). Thus, efficiency in practice is less important to perceived efficiency than characteristics of the user. Similarly, people have preferred less usable over more usable designs, and later reversed opinions as the more usable design becomes more familiar (Kurosu & Kashimura, 1995a, 1995b).

> **H4.** People who use the self-regulatory processes associated with growth mindsets will perceive an app as *easier to use*, regardless of its objective usability, compared with those who exhibit the self-regulatory processes associated with fixed mindsets.
> **H5.** People who use the self-regulatory processes associated with growth mindsets will perceive an app as *more usable*, regardless of its objective usability, compared with those who exhibit the self-regulatory processes associated with fixed mindsets.

Changing Mindsets and Proposed Study

While mindsets are relatively stable and trait-like, they may be changed and have been successfully manipulated in many studies. People with fixed mindsets that have been shifted to growth also exhibit the outcomes expected from those who hold growth mindsets independent of manipulation. For example, dieters primed to have a growth mindset of body weight management showed greater persistence in the face of setbacks (Burnette, 2010). In other studies, people's mindsets have been shifted more growth or fixed over periods of 8 to 12 weeks with interventions occurring only once or twice per week (Blackwell, Trzesniewski, Dweck, 2007; Burnette & Finkel, 2012). Mindsets of computer ability, a domain close to that of interest in the proposed study, affected people's computer-related anxiety and efficacy after an intervention (Martocchio, 1994). To date, however, no research has attempted to change people's mindsets of a more general ability with technology, nor measured their relationship to self-regulation, perceived usability, or actual adoption.

In the proposed study, we will attempt a mindset intervention to improve outcomes with medical technology for older adults. Following the intervention, we will randomly assign participants to use either a high or low usability blood pressure monitoring smartphone app. Following a week of use, we will measure how often the app was used and the user's satisfaction with it. We expect older adults primed to hold a growth mindset of technology ability will use the app more and report greater satisfaction with it, with stronger effects for those using the high usability app. On the basis of the preceding discussion, we will also assess self-regulatory processes and perceptions likely to influence people's decisions to adopt technologies, that we may better understand the relationships of these constructs and make a strong case for the role of mindsets among them.

> **H6.** Participants will be successfully primed to hold either a growth or fixed mindset of technology ability.
> **H7.** People primed to have a growth mindset of technology will be *more likely to adopt* an app, regardless of its objective usability, compared with those primed to have a fixed mindset.

General Plan of Work

Participants

We will recruit 100 older adults from assisted living communities to participate in a study about a "blood pressure monitoring app." Participants will be compensated with a $15 gift card for completion of the first session, and, as an additional incentive to participate in both sessions, a

$30 gift card for completion of the second. Assuming some attrition is likely between sessions 1 and 2, 80 participants are expected to complete data at both collection points, which should be a sufficiently large sample to detect the predicted effects as determined on the basis of historical similar effect sizes and a power analysis.

Materials

Mindset intervention. In the same spirit of prior work that has manipulated mindsets of attributes in other domains using short readings (Burnette, 2010) or longer training sessions with teachers (Blackwell et al., 2007), participants will watch one of two brief videos filmed in the style of a university science news report, discussing the "latest research" on the origins of people's ability to use technology. One intended to promote a fixed belief will stress how those who are particularly adept at learning and using novel technologies are "born, not made." The other, intended to promote a growth belief, will describe the various methods successfully used by people with pervasive technological difficulties to overcome them.

Blood pressure monitoring app. Participants will be instructed to download and use at least once daily one of two blood pressure monitoring apps developed for this study. The two apps will be the same or highly similar in functionality, style, and aesthetics, but will vary in usability (high or low) by systematically manipulating the availability and usage of functionality through common usability principles, e.g. mapping, feedback, visibility, etc. (Norman, 1986). We will verify the success of this manipulation with a usability test, comparing the two interfaces by the number of errors observed and time to accomplish the primary app task.

Measures

Demographic questions. Participants will provide basic demographic information to provide some estimate of the representativeness of the sample, such as age, gender, and highest degree of education completed. Furthermore, these data, and some additional constructs, may be pertinent to the outcomes of interest in the proposed study (Czaja et al., 2006), including breadth of technology usage, general quality of health (Larsen & Kasimatis, 1991), and the frequency with which participants currently monitor their blood pressure.

We will assess breadth of technology usage using a version of the Computer Usage Questionnaire (CUQ; Schroeders & Wilhelm, 2011) that has, in an unpublished study, been adapted to include activities that may be accomplished using other devices (Cronbach's $\alpha = .79$; Pybus, Wagner, & Gillan, 2017). Participants will rate how often they perform an activity in the 8-item instrument on a 5-point Likert scale ("Never" to "Very often"). An example item follows: "How often do you perform the following activity with any device: social networking?"

Manipulation check. After watching the video for the condition to which participants have been assigned, we will assess the initial success of the manipulation using two measures. First, to confirm that the message of the video has been understood, participants will summarize the content of the video in their own words. Second, to assess the degree to which participants have been influenced by the content, participants will rate the degree to which they found the video a credible source of information on a 7-point Likert scale ("Highly credible" to "Not credible at all").

Mindset of technology ability. We will assess the participants' mindsets of technology ability after one week using a 4-item instrument developed by Pybus (2016, Cronbach's $\alpha = .76$), to which participants respond using a 7-point Likert scale ("Strongly agree" to "Strongly disagree"). Half of the items are negatively constructed. An example follows: "Your ability to use technology is something that you just can't change very much."

Goal setting. We will assess the types of goals that participants set with technology using 8 items developed for this study. Half will assess how important such goals are to participants, while the others will assess how specific participants are in making them. An example of a goal importance item includes: "It is important to me that I keep up with new technology." An example of a goal specificity item includes: "I set goals for what I'd like to learn to do with new devices." Participants will rate their agreement with these items using a 7-point Likert scale ("Strongly agree" to "Strongly disagree"). Three of the items are negatively constructed.

Goal operating. We will assess the strategies that participants use to operate towards their goals with technology using 8 items developed for this study. Half will assess the participants' self-regulatory strategies, while the others will assess their self-regulatory abilities. An example of a strategy item includes: "I know where to find the information I need to solve my tech problems." An example of an ability item includes: "When I get the information I need, I can usually solve my tech problems." Participants will rate their agreement with these items using a 7-point Likert scale ("Strongly agree" to "Strongly disagree"). Half of the items are negatively constructed.

Goal monitoring. We will assess differences among participants in monitoring technology-related goals using 8 items developed for this study. Half will assess negative emotions related to technology, while the others will assess how realistic participants' expectations are about reaching their goals. An example of an item assessing negative emotions includes: "I get frustrated when I have to learn a new system for something I already do." An example of an item assessing realistic expectations includes: "I can usually meet my goals when using tech devices." Participants will rate their agreement with these items using a 7-point Likert scale ("Strongly agree" to "Strongly disagree"). Three of the items are negatively constructed.

Perceived ease of use. We will assess participants' perceptions of the app's ease of use using a 4-item instrument (Cronbach's $\alpha = .90$) adapted from Davis (1989) by Venkatesh and Bala (2008). Participants will rate the degree to which they agree with its statements using a 7-point Likert scale ("Strongly agree" to "Strongly disagree"). All items are positively constructed. An example item follows: "I find the app to be easy to use."

Perceived usability. We will use two instruments to assess subjective satisfaction with the blood pressure monitoring app after one week of use: the SUS (Brooke, 1996) and the NPS (Reichheld & Covey, 2006), with which it is commonly paired by practitioners (Brooke, 2013).

The SUS is a 10-item instrument (Cronbach's $\alpha = .90$, Lewis & Sauro, 2009), to which participants respond using a 5-point Likert scale ("Strongly agree" to "Strongly disagree"). Half of its items are negatively constructed. An example follows: "I believe that I would like to use [this app] frequently."

The NPS comprises a single item: “How likely are you to recommend (this blood pressure monitoring app) to a friend or colleague?” Participants respond using a 7-point Likert scale.

Acceptance. We will record the duration and number of times that participants open and use the blood pressure monitoring app directly within the software. These data will be accessible only to the research team.

Design
The proposed study will be a 2 (*fixed* or *growth*) × 2 (*high* or *low usability*) design, with both mindset and app usability as between-subjects factors.

Procedure
Participants will schedule a day to complete an initial assessment, including informed consent, and demographic information. Prior to giving further instructions, we will present participants with one of two brief videos “for an unrelated study,” assigned at random, that discusses the “latest research” on the origins of people’s ability with technology, thereby promoting either a fixed or growth mindset. Next, participants will be told that the purpose of this research is to study the effectiveness of a blood pressure monitoring app, and instructed to download and use the randomly assigned blood pressure monitoring app, at least once per day, and more often as desired, to regularly monitor their blood pressure. At the end of the first session, we will compensate participants, schedule a follow-up session for one week in the future, remind participants of the added incentive to complete the second session, and thank them for their time and help.

After a week of usage, we will assess the participant’s mindset of technology ability, self-regulatory processes, and, after accessing the app’s usage logs, record how often the app was used. After completing a final assessment of the participant’s satisfaction with and perceived usability, perceived usefulness, and perceived ease of use of the app, we will fully disclose the purpose of the study, and inform them of the nature of mindsets of technology ability. At the end of the final session, we will again compensate participants, and thank them for their time and help.

Anticipated Results

Manipulation check
Research team members will independently categorize participants’ summaries of the intervention video as either accurate or inaccurate according to pre-determined criteria; we will assess the degree of inter-rater reliability, convene to discuss discrepancies, and re-categorize as necessary. We will then remove from further analyses any participants who did not trust the credibility of the intervention video, and those who were unable to adequately summarize its contents. With the remaining participants, we will create a composite score for mindset of technology ability, using the sum of responses to all mindset items, reversing scores as needed. We will confirm the efficacy of the intervention (H6) using an independent samples t-test. Participants in the “growth” condition are expected to have a significantly higher mean mindset score than those in the “fixed” condition.

Self-regulatory processes
We will assess the internal consistency, and confirm the factor structure, of the technology-related self-regulation strategy items developed for this study. We expect an acceptable level of internal consistency (Cronbach's alpha > .70), and a 6-factor solution representing each of the two characteristics for the three dimensions of the SOMA model: setting (*goal specificity* and *importance*), operating (*self-regulatory strategy* and *ability*), and monitoring (*negative emotions* and *expectations*).

Mindsets and self-regulatory processes
For this analysis, we will create three composite scores using the sum of responses to the setting, operating, and monitoring items, respectively, reversing scores as needed. We will test the relationships of mindset and self-regulatory processes using a t-test. We expect to observe that the group of participants primed to hold a "growth" mindset of technology ability will have a significantly higher mean score in the setting (H1), operating (H2), and monitoring (H3) dimensions of self-regulatory processes. This would indicate that people with growth mindsets of technology ability are more likely to set specific and personally important goals with technology, to have adequate self-regulatory strategies and abilities to operate towards those goals, and have more realistic expectations of their own progress, and fewer negative emotions provoked by technology.

Self-regulatory processes, perceived ease of use, and perceived usability
We will similarly create composite scores using the PEOU, SUS, and NPS items. We will test the relationship of all self-regulatory processes and PEOU (H4), as well as the relationship of self-regulation and perceived usability (H5), controlling for the usability condition of the app, using a series of multiple regressions. We expect that participants who set specific and personally important goals with technology, who have adequate self-regulatory strategies and abilities to operate towards those goals, and who have more realistic expectations of their own progress, and fewer negative emotions provoked by technology to be significantly more likely to perceive the app as easy to use and usable. We also expect that the usability condition of the app will only slightly predict participants' ratings when including self-regulatory processes in the regression model.

Adoption
We will test differences in adoption using a two-way ANOVA test, with the mindset and usability conditions as factors. We expect that participants in the "growth" condition, as compared with those in the "fixed" condition, will have a significantly higher mean number of times that they opened the app. We expect a similar pattern of results for participants in the high usability condition, as compared with those in the low usability condition. We will also test for interaction effects, and expect that participants in both the "growth" and high usability conditions will have the highest mean of all other groups.

Broader Impacts

This research has an important and direct application for a critical problem facing our society, and improving the health and quality of life for future generations of older adults. This population will likely be required to navigate novel tasks with devices at home as innovations in technology change the way that healthcare providers serve them. We will use a blood pressure monitoring app as a relatively simple example relevant to most people, but expect that these results would transfer to similar devices and services across a broader range of health issues. These results, building upon previous research, would likely extend to other populations and other technologies as well. We will make contact with popular media, as well as industry representatives within healthcare technology, to inform them of the findings of our research, and to initiate relationships with the goal of making its benefits more widely available to the public.

Inherent within the intervention itself is an effort to educate the public, specifically, on the nature of mindsets and how they affect goal achievement. Although our interest in this research is constrained to mindsets of technology ability, we will emphasize in our intervention how mindsets have been shown to influence behavior in many other domains as well. Participants within this study, and those who will later benefit from the intervention, will hopefully benefit not only from a new approach to technology, but other problems encountered in various contexts.

Bringing this research to fruition would contribute to the scholarly community's understanding of how people's beliefs affect their interactions with technology, and importantly, how modifying those beliefs can improve those interactions. We will make every effort to publish this work in the peer-reviewed journals and present it in academic conferences where it will make the most impact. This work would, furthermore, be used as dissertation research in fulfilling the primary investigator's doctoral requirements.

References Cited

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology, 84,* 261–271.

Arnrich, B., Mayora, O., Bardram, J., & Tröster, G. (2010). Pervasive healthcare. *Methods of Information in Medicine*, *49*(1), 67–73.

Barnard, Y., Bradley, M. D., Hodgson, F., & Lloyd, A. D. (2013). Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability. *Computers in Human Behavior*, *29*(4), 1715–1724.

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.

Brooke, J. (1996). SUS: A quick and dirty usability scale. *Usability Evaluation in Industry*, *189*(194), 4-7.

Brooke, J. (2013). SUS: A retrospective. *Journal of Usability Studies*, *8*(2), 29–40.

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,* 721–725.

Burnette, J. L., O'Boyle, E. H., VanEpps, E. M., Pollack, J. M., & Finkel, E. J. (2013). Mind-sets matter: A meta-analytic review of implicit theories and self-regulation. *Psychological Bulletin*, *139*(3), 655.

Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior.* New York, NY: Cambridge University Press.

Centers for Disease Control and Prevention. (2003). Trends in aging—United States and worldwide. *Morbidity and Mortality Weekly Report*, *52*(6), 101.

Charness, N., & Boot, W. R. (2009). Aging and information technology use: Potential and barriers. *Current Directions in Psychological Science*, *18*(5), 253–258.

Chen, L. H., Chen, M. Y., Lin, M. S., Kee, Y. H., Kuo, C. F., & Shui, S. H. (2008). Implicit theory of athletic ability and self-handicapping in college students. *Psychological Reports, 103,* 476–484.

Cury, F., Da Fonseca, D., Zahn, I., & Elliot, A. (2008). Implicit theories and IQ test performance: A sequential meditational analysis. *Journal of Experimental Social Psychology, 44,* 783–791.

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.

Czaja, S., & Schulz, R. (2006). Innovations in technology and aging: Introduction. *Generations*, *30*(2), 6-8.

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. (1975). The role of expectations and attributions in the alleviation of learned helplessness. *Journal of Personality and Social Psychology, 31,* 674–685.

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, *41*(10), 1040.

Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development.* Philadelphia, PA: Psychology Press.

Dweck, C. S. (2008). *Mindset: The new psychology of success*. Random House Digital, Inc..

Fisk, A.D., Rogers, W.A., Charness, N., Czaja, S.J., & Sharit, J. (2009). *Designing for older adults: Principles and creative human factors approaches* (2nd ed.). Boca Raton, FL: CRC Press.

International Organization for Standardization. (1998). ISO 9241-11: Ergonomic requirements for office work with visual display terminals (VDTs). Part 11: Guidance on usability. Retrieved from http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=16883

Kurosu, M., & Kashimura, K. (1995). Determinants of the apparent usability [user interfaces]. In *Systems, Man and Cybernetics, 1995. IEEE International Conference on Intelligent Systems for the 21st Century.* IEEE.

Kurosu, M., & Kashimura, K. (1995). Apparent usability vs. inherent usability: experimental analysis on the determinants of the apparent usability. *Conference Companion on Human Factors in Computing Systems*. ACM.

Larsen, R. J., & Kasimatis, M. (1991). Day-to-day physical symptoms: Individual differences in the occurrence, duration, and emotional concomitants of minor daily illnesses. *Journal of Personality*, *59*(3), 387-423.

Lewis, J. R. & Sauro, J. (2009) The factor structure of the System Usability Scale. *Proceedings of the Human Computer Interaction International Conference (HCII 2009)*, San Diego CA.

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

Norman, D. A. (1986). Cognitive engineering. *User Centered System Design: New Perspectives on Human-Computer Interaction*, *3161*.

Pybus, L., & Gillan, D. J. (2015). Implicit theories of technology: Identification and implications for performance. *Proceedings of the Human Factors and Ergonomics Society 59th Annual Meeting*. Santa Monica, CA: Human Factors and Ergonomics Society.

Pybus, L. (2016). *Implicit theories of technology ability and technology acceptance* (Master's thesis). North Carolina State University, NC.

Pybus, L. Wagner, R. B. & Gillan, D. J. (2017). A comparison of different acceptance models for wearable technologies and relationships with mindsets of technology and mental model development. Unpublished manuscript, North Carolina State University, Raleigh, NC.

Quesenbery, W. (2001). What does usability mean: Looking beyond 'ease of use.' *Proceedings of the 48th Annual Conference, Society for Technical Communication*.

Reichheld, F. F., & Covey, S. R. (2006). *The ultimate question: Driving good profits and true growth*. Boston, MA: Harvard Business School Press.

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

Strayer, D. L., & Kramer, A. F. (1994). Aging and skill acquisition: Learning-performance distinctions. *Psychology and Aging*, *9*(4), 589.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124-1131.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*(2), 273-315.

Zviran, M., Glezer, C., & Avni, I. (2006). User satisfaction from commercial web sites: The effect of design and use. *Information & Management*, *43*(2), 157-178.