ABSTRACT

PYBUS, LAWTON RANDALL. Change Your Belief, Change Your Device: Manipulating Implicit Theories to Improve Adoption Outcomes. (Under the direction of Dr. Douglas J. Gillan).

Understanding the influences behind a person's choice to use or not to use a tool or system is a common, practical research problem. Whereas much of the existing literature has focused on improving the system or its context of use, comparatively little work has sought to understand the varying beliefs and motivations of the user. The study of users' implicit beliefs about the nature of technological ability is of particular interest, as these beliefs have been shown to influence other important determinants of adoption, and, in other domains, have been successfully manipulated to improve outcomes. Building on this work, it is expected that people who conceptualize technological ability as an unchanging quality are more likely to flounder in response to the problems encountered while using a system. They are therefore less likely to perceive the system as easy to use, which perceptions are strongly and negatively correlated with later usage. The present research examined the possibility of an implicit theory manipulation to increase adoption via these hypothesized processes in two studies. In the first, participants in a laboratory attempted to complete a series of tasks in Microsoft Excel, using a spreadsheet which automatically deleted their progress midway. In the second, participants recruited online were instructed to learn a complex and unfamiliar organizational app, Evernote, over the course of one week, and afterwards, to report the number of setbacks encountered. Across the two studies, the manipulation successfully shifted people's implicit theories of technology ability. Furthermore, results largely supported the hypothesized processes by which implicit theories would influence adoption, though interpretation was somewhat mitigated by the influence of resilience. The converging evidence from these studies, each with different contexts and systems, indicates that these results may be generalizable. This work thus helps to bridge adoption and implicit theory

research, and suggests a possible intervention for practitioners. Potential applications are discussed.

Change your belief, change your device: Manipulating implicit theories to improve adoption outcomes

by
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DEDICATION

Ad majorem Dei gloriam

BIOGRAPHY

Lawton Pybus is a doctoral candidate in the Human Factors and Applied Cognition program within the Department of Psychology at North Carolina State University. Pybus earned a Bachelor of Science, *summa cum laude*, in Psychology with a minor specialization in English from Abilene Christian University in 2012, and a Master of Science in Human Factors and Applied Cognition from North Carolina State University in 2016. His research interests include user motivations and beliefs about technology, technology adoption, and mental model development. During his time in graduate school, he has been invited to present his work at a number of conferences, including the annual meetings of the Human Factors and Ergonomics Society, the Cognitive Aging Conference, and the North Carolina Cognition Group. His work has been featured in the North Carolina State University Press and in popular publications such as *Fast Company Design*. He has served as an instructor for an undergraduate course in human factors, as president of the NCSU student chapter of the Human Factors and Ergonomics Society, as coordinator of the inaugural meeting of the Southeastern Human Factors Applied Research Conference, and as an intern with the Cabela's User Experience team. He has accepted a position with MeasuringU as a user research consultant to begin after graduation.

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INTRODUCTION

Why do people choose to purchase one technological device over another, whereas others prefer not to use such a device at all? Why do some resist updating their devices until circumstances force them to do so, whereas others seem to enjoy researching and comparing the latest technologies? Researchers in human factors and associated disciplines have been interested in understanding these and related questions for many years. Despite the ubiquity of consumer technologies (Anderson, 2015), understanding technology adoption remains important today for many practical reasons. For successful evidence-based interventions administered via technological systems to be effective, for example, they must be used by the people they are intended to help. Likewise, industry practitioners must also promote adoption to enhance profits and to meet other organizational goals.

Several important models have emerged from efforts to understand adoption, including the Technology Adoption Lifecycle (Beal & Bohlen, 1967), the Technology Acceptance Model (TAM; Davis, 1989) and its later expansions (e.g., TAM 3; Venkatesh & Bala, 2008), and related models such as the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Thong, & Xu, 2012). Factors that have been found to influence adoption include: beliefs and personality traits of the user, perceptions of the system, the context of use, and interactions among these three factors. Perceived ease of use and perceived usefulness, for example, are the primary predictors of usage in TAM (Davis, 1989). Although these models have predictive value, they are not usually diagnostic—that is, they cannot suggest changes that would improve adoption. Certain antecedent elements included in the model, such as usability and perceived enjoyment, are susceptible to improvements by design (Venkatesh & Bala, 2008). Human factors

research has often been applied to make these kinds of enhancements; even so, individual differences in adoption remain to be explained (Fisk, Rogers, Charness, Czaja, & Sharit, 2009). To more fully address these, we may instead consider how the user's beliefs influence behavior, a common approach in other psychological disciplines (e.g., Bandura, 1977, Gagné & Deci, 2005). In the present research, we examined an implicit theory intervention as a potential means of improving technology adoption outcomes.

Implicit Theories, Motivation, and Self-Regulation

Implicit theories are beliefs about the nature, origin, and malleability of human abilities (Dweck, 1986, 2008). Those who believe that an attribute is unchangeable, as in the example of one who conceives of intelligence as a quality fixed by genetics at birth, are called *entity theorists* (Dweck & Leggett, 1998). In contrast to this view are *incremental theorists*, who consider an attribute developable, such as a person who believes intelligence can be improved with education and training. These beliefs are implicit in that they are often not consciously held. For any given ability and population, these beliefs have been observed in roughly equal proportions (Dweck, Chiu, & Hong, 1995a). Although they are classified broadly into these two dichotomous groups, they exist in a more-or-less continuous range.

People hold distinct implicit theories in different domains, of which a wide variety have been identified (Dweck, Chiu, & Hong, 1995b). Initially studied in an academic context (Dweck, 1986), researchers have examined people's implicit beliefs of moral effort (Dweck et al., 1995b), leadership (Burnette, Pollack, & Hoyt, 2010), weight management (Burnette, 2010; Burnette & Finkel, 2011), and, most relevant to the present research, technology ability. Previous work has established that people hold a range of beliefs about the nature of the ability to use technology,

and that these beliefs are related to their performance (Pybus & Gillan, 2015; Lee, Heeter, Magerko, & Medler, 2012), as well as some predictors of adoption (Pybus, 2016). Although people with different implicit theories do not differ in their ability, these findings are consistent with research in other domains, in which, for example, people with implicit theories of negotiating ability were more successful in negotiating tasks (Kray & Huselhuhn, 2007).

The direct relationship of implicit theories and goal achievement, however, is relatively weak (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013). Rather, incremental and entity theories are strongly associated with different motivations, goals, and approaches towards achieving those goals via self-regulatory processes (Dweck, 1986; Burnette et al., 2013). Consequently, Burnette, et al. (2013) proposed—in the Setting, Operating, Monitoring, Achieving (SOMA) model—that the primary way in which implicit theories influence domain-related outcomes is through these intermediary processes. The evidence for SOMA suggests that incremental theorists are more likely than entity theorists to choose for themselves a mastery goal in that domain—that is, with an intrinsic motivation of learning for its own sake. Their strategies in reaching that goal are more likely to be oriented towards learning, and they therefore exhibit more persistence in the face of setbacks (Dweck, 1986). Indeed, setbacks are even expected as a normal part of the learning process (Dweck, 2000). They give more conscientious effort to realizing their goals, and thus tend to have more realistic expectations of their progress towards doing so (Burnette et al., 2013).

On the other hand, entity theorists are more extrinsically motivated. They are more likely to pursue *performance goals*—in other words, to meet a requirement (as is the case with *approach-oriented goals*) or to avoid negative consequences (as is the case with *avoidant-*

oriented goals). Due to their fixed view of the ability, they are more likely to adopt helpless strategies for reaching their goals (Dweck & Leggett, 1988). Setbacks appear insurmountable and beyond one's personal control, leading to frustration. Tensions arise when they are confronted with incongruities between their expected and actual progress, which often manifest in negative emotions (Burnette et al., 2013).

Technology Adoption as Goal-seeking Behavior

Motivation and self-regulation are thus key for understanding the goals people set for themselves and how they approach them. People's goals are also critical for understanding the technologies they adopt, as they use tools and technologies to reach specific goals (Norman & Draper, 1986). As such, their motivations play a role in most stages of interaction with technology (Norman & Draper, 1986; Szalma, 2014). This relationship has already been recognized to an extent within the adoption literature. Some of the more recent models, including TAM 3 and UTAUT 2, include factors such as performance expectancy, hedonic value, and job relevance, which are adapted from the expectancy-value framework of motivation (Venkatesh & Bala, 2008; Venkatesh et al., 2012; Wigfield & Eccles, 2000). Previous work has also examined the theoretical overlap of antecedent constructs influencing adoption with those motivational and self-regulatory processes related to implicit theories, with mixed results (Pybus, 2016). This research found some weak associations with intentions to use, but no measures of actual usage or adoption were taken. Among the strongest relationships observed, however, were those between implicit theories of technology ability, self-efficacy, and computer anxiety. Computer anxiety and self-efficacy are both user characteristics that influence initial judgments of perceived ease of use, an especially important predictor of decisions to adopt unfamiliar systems.

These relationships are likely due to how people with different implicit theories interpret and respond to setbacks. People often encounter setbacks when trying to learn an unfamiliar system, either due to age-related performance decrements (Fisk et al., 2009), negative transfer, human error, or usability issues, among other reasons (Norman, 2013). Entity theorists would more likely believe these setbacks to reflect personal limitations which cannot be overcome. This would result in diminished technology-related expectations, as, for instance, measured by computer self-efficacy. Their helpless strategies and unmet expectations would, therefore, also be observable in a more negative affective response and less persistence in efforts to realize their goals. These responses would lead to fewer intentions to use a system, as has previously been observed (Pybus 2016), and ultimately, a lower likelihood of adoption.

Present Research and Hypotheses

The present research was designed to understand how implicit theories of technology ability influence adoption in two studies. Although implicit theories are relatively stable, they are susceptible to change (Dweck, 2008). In other domains, they have been temporarily shifted in laboratory studies; longer-term interventions have shown some success as well (Burnette, 2010; Blackwell et al., 2007). Previous researchers have successfully manipulated people's implicit theories of a related domain—computer learning ability—and observed that incremental theorists reported less anxiety than did entity theorists (Martocchio, 1994). Martocchio's primary outcome of interest was not adoption, however, but declarative knowledge of a system after training. The present study thus expands the adoption literature by suggesting a possible intervention. By measuring adoption and testing the theoretical mechanism proposed by implicit theory literature,

especially in the SOMA model, it also builds upon previous work that integrates these two bodies of research.

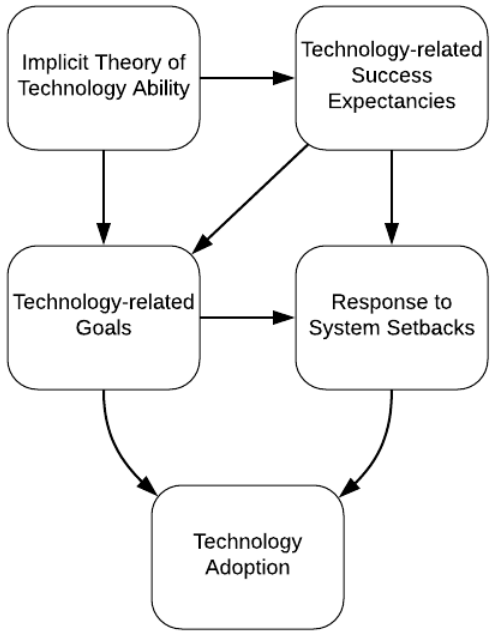

Figure 1. Theoretical model tested in the present research

We expect that incremental theorists will have a more adaptive response to setbacks, and that this persistence will be positively related with levels of adoption and its related antecedents, such as perceived ease of use. Drawing from expectancy-value theory, we predict that people's success expectancies with technology in general will mediate the relationship between their implicit theories of technology ability and their response to system-specific setbacks. Furthermore, we predict that people's implicit theories and expectancies will be related to differing technology-related goals, as in the above discussion. These goals will further mediate the relationship between implicit theories, expectancies, and setback responses. Refer to *Figure 1* for a representation of the theoretical model representing our general hypotheses.

In the first study, we examined how participants in two implicit theory conditions differed in their perceptions of a spreadsheet task that has been programmed to create unexpected problems, as well as their reactions to those setbacks. A spreadsheet task was chosen as a representative system of general interest and familiarity. Implicit theories, however, are believed to more strongly affect learning contexts within the domain (Burnette et al., 2013). Thus, in the second study, we examined how participants in the two conditions differed in their technology-related goals, their response to setbacks, their perceptions, and their adoption of an unfamiliar and complex smartphone app. The app, Evernote, was chosen on the basis of a pilot study in which participants rated it as having the greatest general interest among apps similar in familiarity and complexity.

STUDY 1

Method

Participants. We recruited 88 university students (aged 18 and over, M_{age}=19.22 years, *SD*=1.36 years; 64% (*n*=56) males) from an introductory course in psychology at a large southeastern research university. 69% were first- or second-year students. Participants were compensated for their participation with partial fulfillment of course requirements.

Materials. All participants used an Apple iMac all-in-one workstation running Microsoft Excel v.16 in a quiet laboratory environment to complete the task. Participants completed demographic and post-task questionnaires on the iMac using the Qualtrics web survey platform. Recordings of screen activity were produced in the background using Apple QuickTime Player.

Procedure. We used procedures similar to those used in previous research that has manipulated implicit theories. After completing an informed consent form, participants were

asked to read a brief article for an "unrelated study," written in the style of a popular psychology report, that presents evidence intended to promote either an entity or incremental implicit theory of technology ability, depending on the condition to which they have been randomly assigned (see *Appendix A*). The article for the entity condition stressed the fixed nature of the ability, whereas the incremental condition article emphasized the malleable quality of the ability. Both cited twin studies, longitudinal and intervention research as evidence, and concluded with a specific, emphatically-worded summary statement. After participants read the article, they were asked a series of alleged "reading comprehension questions," detailed below, to ensure that the intended message was understood and found persuasive. Following this, they filled out a demographic questionnaire with items such as age, gender, breadth of technology usage, previous experience with spreadsheets, and the Brief Resilience Scale (BRS; Smith, Dalen, Wiggins, Tooley, Christopher, & Bernard, 2008).

Next, the experimenter instructed participants about the nature of the study, which was purportedly to test the usability of Microsoft Excel. They were asked to complete successive tasks in a spreadsheet over 15 minutes, and informed that they may consult an online help system or the experimenter for assistance, or, if desired, quit the task at any time. Unknown to participants, the first spreadsheet contained a hidden macro that caused the spreadsheet to unexpectedly and irretrievably delete all of the spreadsheet's contents after a random number of clicks between 10 and 20. After this setback event, participants needed to inform the experiment before proceeding. At this point, the experimenter opened a "back-up copy,"—that is, an identical but normal spreadsheet—and participants had the remainder of the 15 minutes to complete the study task without any additional experimenter-created problems.

After completing the spreadsheet task, participants responded to several brief self-report instruments to measure their general technology-related expectancies, affective state, and the perceived usability of the software. Finally, participants were informed of the true nature of the experiment in a funnel debriefing procedure, before being thanked for their time and participation.

Measures

Attention check and suspicion. We asked participants several questions presented as measuring reading comprehension to assess attention and suspicion of the manipulation. The questions asked were, "How did the article describe technology ability?" and "What were the most convincing arguments in this article?" Participants who correctly identified the message of the article and who recalled any of its arguments were assumed to have paid attention.

In the funnel debriefing procedure, participants were asked, "What did you think about the study?" followed by "What did you think was the purpose of the study?" and "What did you think about the article from the beginning of the study?" After answering these questions, participants were informed of the true nature of the study. Participants who stated disagreement with the article or answered in the attention check that none of its arguments were compelling and mentioned a possible connection between it and the study were categorized as having clear suspicion. Participants who made equivocal statements about the article's connection to the study, or about the arguments in the article without explicit disagreement were categorized as having some possible suspicion. All others were categorized as having no suspicion.

Manipulation check. We assessed the effectiveness of the implicit theory manipulation using four items used previously by Pybus (2016) to assess implicit theories of technology use.

Using a 7-point scale, participants rated the degree to which they agreed or disagreed with statements about the nature of technology ability. The following is one example: "You have a certain amount of technology ability, and you really can't do much to change it." *Appendix B* contains all items used in this scale and all other measures used in this research.

Brief Resilience Scale. We measured participants' resilience using the BRS, a 6-item instrument (Cronbach's α=.80; Smith et al., 2008). Half of its items are negatively constructed. An example item is: "It is hard for me to snap back when something bad happens."

Prior experience. We assessed general 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 computers and other devices, such as smartphones (Cronbach's α=.79; Pybus, Wagner, & Gillan, 2017). Participants rated how often they perform an activity in the 8-item instrument on a 5-point Likert scale ("Never" to "Very often"). An example item is: "How often do you perform the following activity with any device: social networking?"

In addition, to account for the influence of prior spreadsheet usage in particular on the outcomes of interest in this study, we also asked participants to rate their competence using spreadsheets on a 5-point Likert scale ("Novice" to "Expert"), report the duration they have used spreadsheets, and report the frequency they have used spreadsheets in the past year.

Technology-related expectancies. We assessed participants' general technology-related expectancies using four items (Cronbach's α=.95) adapted from Compeau and Higgins (1995) by Venkatesh and Bala (2008). Participants rated the degree to which they agree or disagree with

the items using a 7-point scale. An example item includes: "I can usually complete technological tasks if there is no one around to tell me what to do as I go."

Task performance. At the end of the study, we saved participants' progress in the spreadsheet task and coded their response to each instruction in the task. Thus, we were able to indicate the number of items completed as well as the number of items completed correctly. Because the unexpected setback event occurred at different points in the 15 minutes for each participant, we have used the proportion of correctly completed items to all items completed in order to make comparisons between participants.

Two further measures of performance were taken. Participants were informed that they were free to quit the task at any time; however, none elected to do so. We also instructed participants to use an online help system if desired. We recorded their screen activity to determine the number of assists used during the task.

Affective response to setbacks. Participants self-reported affective response to setbacks using the International Positive and Negative Affect Schedule, Short Form (I-PANAS-SF, Thompson, 2007, Cronbach's α=.74), a 10-item abbreviated form of the Positive and Negative Affect Schedule (Watson & Clark, 1988).

Perceived usability. We used two instruments to assess perceived usability as a theoretical precursor to adoption: the System Usability Scale (SUS; Brooke, 1996) and the Net Promoter Score (NPS; Reichheld & Covey, 2006), which are commonly paired by practitioners (Brooke, 2013). The SUS is a 10-item instrument (Cronbach's α=.90, Lewis & Sauro, 2009), to which participants respond using a 5-point Likert scale ("Strongly agree" to "Strongly disagree"). An example item is: "I believe that I would like to use this system frequently." Half

of the instrument is negatively constructed. The NPS comprises a single item: "How likely are you to recommend this system to a friend or colleague?" Participants responded using a 10-point scale.

Intentions to use. We measured participants' intentions to use Microsoft Excel using three items (Cronbach's α=.95) adapted from Davis, Bagozzi, and Warshaw (1989) by Venkatesh and Bala (2008). Participants rated the degree to which they agreed or disagreed with the items using a 7-point scale. An example item includes: "Assuming I had access to Microsoft Excel, I intend to use it."

Results

Refer to Tables 1 and 2 for the means, standard deviations, and intercorrelations of all variables used in this study. The manipulation was correlated only with implicit theory and suspicion, such that people in the incremental condition were less likely to be suspicious of the manipulation. Negative affect was not correlated with any predictor or outcome except SUS scores.

The SUS and NPS were strongly correlated. Furthermore, all relationships between SUS or NPS scores and other measures are similar in direction and strength. We have therefore only used SUS scores in further analyses. The number of assists used was correlated only with SUS scores, such that people who rated Excel with a higher score tended to need less help. All other significant relationships will be further tested according to our hypotheses using path analysis.

Table 1.
Means and Standard Deviations of Study 1 Variables

	Variable	*M*	*SD*
1	Prior Excel Experience	5.26	2.06
2	Breadth of Technology Usage	24.45	4.38
3	Resilience	14.94	3.55
5	Suspicion	.56	.68
6	Implicit Theory of Tech. Ability	18.28	4.61
7	Tech-related Expectancies	12.00	2.69
8	Positive Affect	9.83	4.16
9	Negative Affect	3.08	3.46
10	SUS Score	55.03	17.83
11	Net Promoter Score	6.61	2.31
12	Intentions to Use Excel	6.94	2.98
13	Proportion Correct	.84	.22
14	Number of Assists	1.66	1.39

Table 2.
Intercorrelations of Study 1 Variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Experience													
2	Tech. Usage	.14												
3	Resilience	.09	.11											
4	Condition	-.01	-.07	.01										
5	Suspicion	.20	.09	-.07	-.39***									
6	Implicit Theory	.14	.03	.27*	.50***	.07								
7	Expectancies	.17	.24*	.26*	.02	.17	.19							
8	Pos. Affect	.07	.10	.01	-.08	.03	.07	.31**						
9	Neg. Affect	-.06	-.04	-.17	.08	.01	-.19	-.10	.07					
10	SUS Score	.37***	.10	.12	-.01	.13	.24*	.43***	.43***	-.36***				
11	NPS	.32**	.09	-.08	-.04	.08	.09	.29**	.51***	-.02	.62***			
12	Intentions	.48***	.09	-.11	-.07	.30**	.12	.38***	.46***	.07	.62***	.74***		
13	% Correct	-.16	.20	-.12	-.06	-.07	-.13	.09	.30**	-.02	.23*	.15	.22*	
14	Assists	-.16	.00	-.04	-.19	-.02	-.16	-.13	-.20	.00	-.29**	-.15	-.20	.04

* $p<.05$, ** $p<.01$, *** $p<.001$

Manipulation check. An analysis of covariance (ANCOVA) with suspicion and resilience as covariates indicated that the manipulation effectively shifted implicit theories of technology ability ($F(1,79)=16.09$, $p<.001$, $\eta^2=.13$), with participants in the entity condition having a more entity theory ($M=16.38$) than participants in the incremental condition ($M=21.94$). Implicit theories were also influenced by suspicion of the manipulation ($F(2,79)=4.79$, $p=.011$, $\eta^2=.08$) and resilience ($F(1,79)=11.99$, $p<.001$, $\eta^2=.10$). Participants exhibiting clear suspicion of the manipulation ($M=19.67$), as well as those with a greater than median resilience score

(*M*=18.73) had a more incremental theory than participants with no or unclear suspicion (*M*=18.11) or a less than median resilience score (*M*=17.59).

Path analysis. See *Figure 2* for a visual representation of the following analyses and relationships between variables discussed. Each link has been labelled with a lowercase letter in parentheses to indicate which analyses produced its weight. The regression equations used in this path analysis included all variables mentioned and any possible interaction terms as suggested by correlations (see Table 2), and was calculated using conditional process analysis (Hayes, 2013), with bootstrap-generated confidence intervals using 5,000 samples from the original dataset. Only significant interactions have been reported. In the following sections, the relationships and subcomponent analyses are described in greater detail.

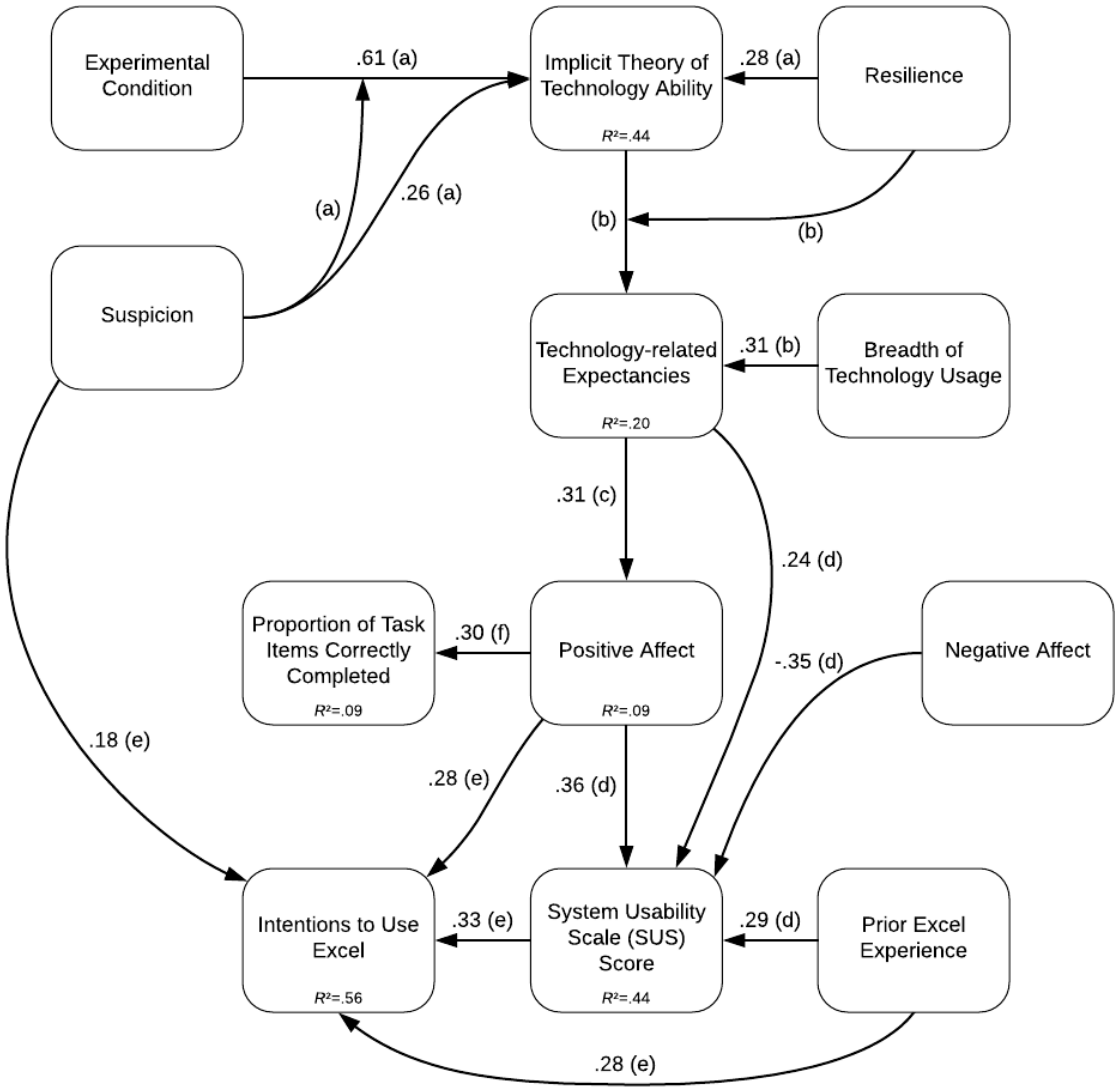

Figure 2. Study 1 path analysis model, link labels indicating subcomponent analyses

Implicit theories. *(a).* Implicit theories of technology ability were influenced by the manipulation (β=.61, $t(85)=6.65$, $p<.001$, 95% CI [.43, .79]), suspicion of the manipulation (β=.26, $t(85)=2.72$, $p=.008$, 95% CI [.07, .45]), and resilience (β=.28, $t(85)=3.22$, $p=.002$, 95% CI [.11, .45]), when controlling for breadth of technology usage, $F(6,79)=10.54$, $p<.001$, $R^2=.44$. Participants in the incremental implicit theory condition, participants who were more suspicious of the manipulation, and participants who were more resilient reported a more incremental

implicit theory. There was a significant interaction of manipulation and suspicion ($t(85)=-2.05$, $p=.044$), such that the manipulation effect on implicit theory for participants in the entity condition diminished at higher levels of suspicion (see Figure 3).

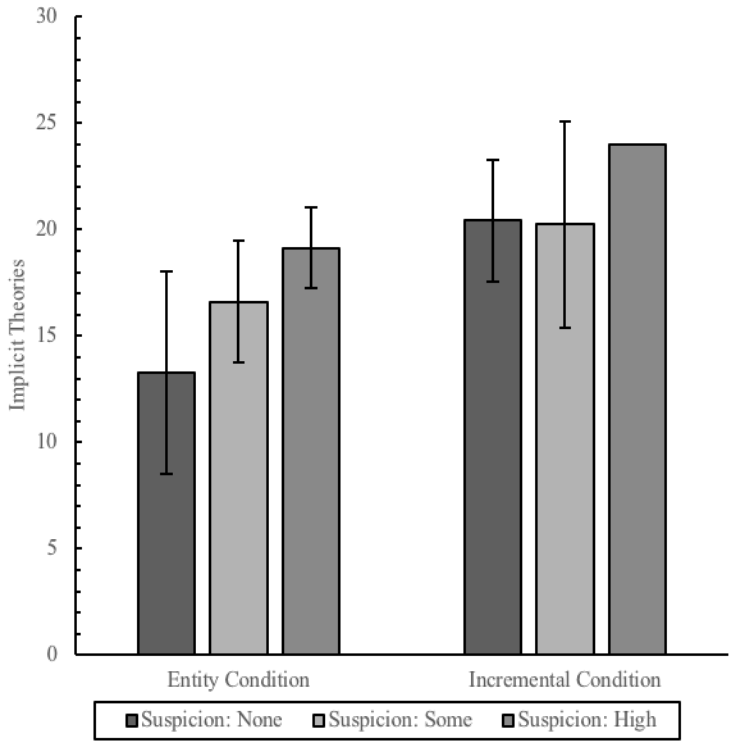

Figure 3. Manipulation by suspicion interaction on implicit theory, bars indicating standard deviations, suspicion group sizes as follows: none, $n=48$; some, $n=31$; high, $n=9$

This and all following analyses were re-run using a subset of the sample excluding participants with clear suspicion. The overall pattern of results was similar, with most beta weights and R^2 values within ±.05 of those reported here, and none losing statistical significance or changing direction, with one expected exception: the manipulation by suspicion interaction effect became nonsignificant. Therefore, we have henceforward reported results using analyses of the full sample.

Expectancies. *(b).* Technology-related expectancies were affected by implicit theory and breadth of technology usage (β=.31, $t(85)=2.84$, $p=.006$, 95% CI [.09, .52]) when controlling for resilience, $F(5,80)=4.00$, $p=.003$, $R^2=20$. Participants with a more incremental implicit theory, and participants who use a wider breadth of technologies also reported higher levels of technology-related expectancies. There was a significant interaction of implicit theory and resilience ($t(85)=2.67$, $p=.009$), such that implicit theory only affected technology-related expectancies at higher levels of resilience (see Figure 4).

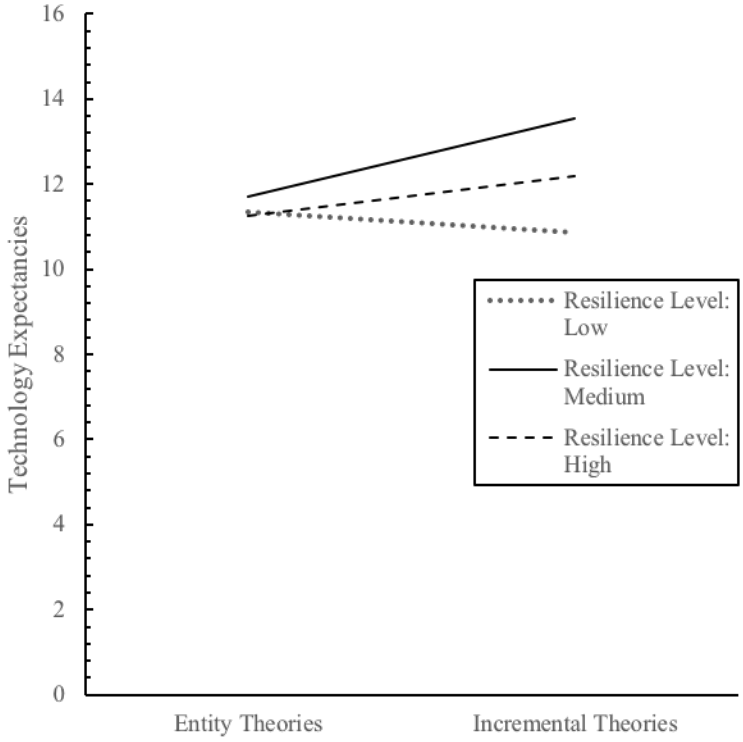

Figure 4. Implicit theory by resilience interaction on technology-related expectancies, produced using median-split implicit theory and tertile-split resilience scores

Positive affect. *(c).* When controlling for implicit theory, positive affect was affected by technology-related expectancies (β=.31, $t(85)=2.88$, $p=.005$, 95% CI [.09, .52]), $F(2,83)=4.34$, $p=.016$, $R^2=.09$, such that people with higher technology-related expectancies reported more

positive affect. A near-significant index of moderated mediation (.05, 95% CI [-.002, .178]) indicated that there was no total effect of implicit theory on positive affect.

Perceived usability. *(d).* System Usability Scale scores were affected by technology-related expectancies (β=.24, $t(85)=2.70$, $p=.008$, 95% CI [.06, .42]), positive affect (β=.36, $t(85)=4.23$, $p<.001$, 95% CI [.19, .53]), prior spreadsheet experience (β=.29, $t(85)=3.45$, $p<.001$, 95%CI [.12, .45]) and negative affect (β=-.35, $t(85)=-4.26$, $p<.001$, 95% CI [-.51, -.19]), when controlling for breadth of technology usage and suspicion, $F(6,79)=12.47$, $p<.001$, $R^2=49$. People with higher levels of prior spreadsheet experience, people with higher technology-related expectancies, and people reporting higher levels of positive affect rated Excel with higher SUS scores. The effect of technology-related expectancies on SUS scores was partially mediated by positive affect (indirect effect=.11, 95% CI [.03, .26]; see Table 3). In addition, people reporting higher levels of negative affect rated Excel with lower SUS scores.

Table 3.
Direct, Indirect, and Total Effects in Studies 1 and 2

Study	Predictor	Outcome	Direct	Indirect	Total
1	Tech. Expectancies	SUS Score	.24	.11	.35
		Proportion Correct		.06	.06
	Positive Affect	Intentions to Use Excel	.28	.11	.39
2	Experimental Condition	T2 Implicit Theory		.30	.30
		Tech. Expectancies		.18	.18
	Implicit Theory	Avoidance-oriented Goals		-.09	-.09
	Mastery Goals	Perceived Ease of Use	.37	.12	.49
		Perceived Usefulness	.34	.22	.56

All effects are significant non-zero effects at 95% confidence intervals.

Intentions to use. *(e).* Intentions to use Excel were affected by SUS scores (β=.33, $t(85)=3.46$, $p<.001$, 95% CI [.14, .52]), positive affect (β=.28, $t(85)=3.24$, $p=.002$, 95% CI [.11,

.45]), prior spreadsheet experience (β=.28), and suspicion of the manipulation (β=.17, $t(85)=2.14$, $p=.035$, 95% CI [.01, .32]), when controlling for technology-related expectancies, $F(6,79)=16.72$, $p<.001$, $R^2=56$. People with higher levels of positive affect, people who rated Excel higher with SUS scores, people with more prior experience using spreadsheets, and people who were suspicious of the manipulation also reported more intentions to use Excel. The effect of positive affect on intentions was partially mediated by SUS scores (indirect effect=.11, 95% CI [.03, .24]; see Table 2).

Performance. *(f).* The proportion of correctly completed items in the task was affected by positive affect (β=.31, 95% CI [.08, .53]), with an indirect mediated effect of technology-related expectancies (indirect effect=.09, 95% CI [.01, .25]; see Table 2), $F(2,79)=4.02$, $p=.021$, $R^2=.09$. People with more positive affect also completed a higher percentage of items correctly.

Discussion

When controlling for the effects of resilience, breadth of technology usage, and prior experience with similar tasks, we found support for the hypothesized relationships between implicit theories, technology-related expectancies, response to setbacks, and adoption. Although our manipulation was effective, the incremental condition was most effective, and strengthened in participants with high levels of resilience. We did not observe a mediated effect of implicit theories on positive affect via technology-related expectancies, although such an effect did appear to be near statistical significance; otherwise, the results reflected our theoretical model.

We have previously observed that implicit theories and technology-related expectancies have a strong relationship with negative affect (Pybus, 2016), a finding that comports with the SOMA model (Burnette, et al., 2013). Contrary to that expectation, the present research found

this relationship with positive affect but not with negative affect. This may be due in part to the stronger shift towards an incremental implicit theory caused by our manipulation, as discussed above. Furthermore, the scale items used to measure negative affect may be less directly relevant to the task and setbacks than measures of negative affect used in previous studies. For example, the I-PANAS-SF asks, "Right now, to what extent do you feel: anxious." Contrast this with a measure which specifically asks participants to rate the frustration one would feel if required to learn a new system, as was used by Pybus (2016). Nevertheless, negative affect, along with positive affect, were strong predictors of SUS scores, as were technology-related expectancies, and prior spreadsheet experience.

The relationship of technology-related expectancies, positive affect, and performance builds upon previous work that has found an influence of implicit theories on performance (Pybus & Gillan, 2015) by indicating the intermediary processes.

Interpretation of these results should be considered with the following limitation. As participants completed the affect measure following the task, it is possible that those participants who performed better on the task reported more positive affect because of their performance and not the other way around (i.e., affect influenced their performance, as indicated in our theoretical model). Participants did not, however, receive any feedback on their performance. For this reason, and on the basis of previous research discussed above, we argue for the directionality of the relationship reported here.

Only perceived usability, via SUS scores—a commonly used predictor of adoption—and intentions to later use Excel were measured, not any objective measure of later usage or adoption. Furthermore, one could reasonably argue that these effects may only manifest in brief,

controlled, laboratory studies. Therefore, in Study 2, we sought to address these concerns by examining how people navigate technological challenges and their actual usage in a more realistic field experiment.

To that end, we asked that participants download and learn to use an unfamiliar and complex smartphone app over a period of one week. Whereas previous researchers have implemented long-term implicit theory interventions, a weekly information "treatment" similar to the manipulation used in this study has been sufficient to produce lasting belief change (Blackwell, Trzesniewski, & Dweck, 2007). Rather than control the setbacks that participants encounter and recording their emotional responses as we did in Study 1, participants reported the issues they encounter. We also included measures of actual usage.

STUDY 2

Method

Participants. We recruited participants online from Amazon's Mechanical Turk platform. Participants were required to meet the following criteria: they must be residents of the United States, they must have successfully completed at least 1,000 other tasks on the platform with at least an 80% overall successful completion rate, and they must not have used Evernote in the past year. We compensated participants at an average rate of $4.53, weighting completion of time 2 (T2) at an average of 3.3x the compensation for time 1 (T1) to encourage completion of the study. Participants also received email reminders during the week concerning the study and its instructions. Of the 152 participants who completed T1, a final N=120 (M_{age}=33.37 years, SD=8.92 years; 61% (n=73) females) completed T2, for an attrition rate of 21%. Participants who did not complete the second portion of the study did not systematically vary from those who

completed both, either in age (M_{age}=37.22, SD=12.77, t(150)=1.97, p=.051), sex (66% females), experimental condition (51% incremental), implicit theory (M=19.44), resilience (M=15.69), or breadth of technology usage (M=25.00). These may be compared with the final sample using Table 4. 75% of the sample reported having either some university education or a four-year university degree.

Procedure. Recruitment materials explicitly stated that the study required participants to use Evernote. After random assignment, participants were instructed to read the article associated with their experimental condition—promoting either the entity or incremental implicit theory of technology ability—as in Study 1. This was followed by attention and manipulation check questions, also as in Study 1. Participants then completed a brief demographic questionnaire which also included the BRS and items intended to assess their breadth of technology usage, success expectancies for general technological tasks, and technology-related goals. Next, participants were informed that the purpose of this study is to test the usability of Evernote, a popular information organization app. They were instructed to: download the app; place it on the home screen of their mobile phones; use it at least once per day over the course of the next week; complete a series of instructions intended to orient novice users to the app's functionality; and, more generally, gain a basic familiarity and proficiency with the app. At the end of T1, participants provided a screenshot of the app on the home screen of their device. On the fourth day, or roughly halfway between the two sessions, we sent participants an additional reminder via email about the study, instructions, and the additional incentive to complete the study.

At the beginning of the T2, participants selected from a list of setbacks experienced while using the app and rated their affective response to those setbacks. They also rated perceptions of

the app's ease-of-use and usefulness, and reported the number of notes created in it. Finally, as in Study 1, we informed participants of the true nature of the study, before thanking them for their time and participation.

Measures

The following measures were common to both Studies 1 and 2: the attention and manipulation checks, breadth of computer usage, technology-related expectancies, and the BRS. All measures of these measures were the same in both studies. See the Method section of Study 1 for the description of these measures. The following sections describe the measures that were unique to Study 2.

Technology-related goals. We adapted an instrument developed by Elliot & Church (1997) to measure participants' technology-related goals. The scale intended to assess avoidant-oriented goals (Cronbach's α=.81) comprised 5 items, such as: "My fear of performing poorly with new technologies is often what motivates me to learn." The scale intended to assess approach-oriented goals (Cronbach's α=.85) comprised 6 items, such as: "It is important to me to keep up with technology more than my peers." The scale intended to assess mastery goals (Cronbach's α=.88) comprised 6 items, such as: "It is important for me to understand new technologies as thoroughly as possible." All items were positively constructed. The full scales and factor loadings are provided in *Appendix C*.

Response to setbacks. Participants were prompted to select, from a list, which setbacks, if any, were encountered that affected their progress in completing the task. The list of representative setbacks was produced using violations of usability principles (Norman, 2013) and barriers to adopting consumer technologies (Venkatesh et al., 2012), including an option

indicating "Other, please specify." An example is: "I wasn't sure where to go for help." Participants also rated how upsetting and frustrating the setbacks were, using 7-point scales.

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

Perceived usefulness. We assessed participants' perceptions of the app's usefulness using a 4-item instrument (Cronbach's α=.87) adapted from Davis (1989) by Venkatesh and Bala (2008). Participants rated the degree to which they agreed with its statements using a 7-point scale ("Strongly agree" to "Strongly disagree"). All items are positively constructed. An example item follows: "Using Evernote increases my productivity."

Usage. We asked participants a single question—"How many notes have you created with Evernote?"—to measure usage of the app.

Results

Refer to Tables 4 and 5 for the means, standard deviations, and intercorrelations of all variables used in this study. Resilience, implicit theories, and expectancies were all correlated with mastery goals, avoidant-oriented goals, and negative affect. Approach-oriented goals were only correlated with breadth of usage, mastery goals, perceived ease of use, and perceived usefulness—and notably, not any of the predictors of interest in this study.

Table 4.
Means and Standard Deviations of Study 2 Variables

	Variable	*M*	*SD*
1	Breadth of Tech. Usage	23.94	4.64
2	Resilience	15.80	5.74
4	Suspicion	.29	.69
5	T1 Implicit Theory	18.69	5.28
6	T2 Implicit Theory	20.00	4.78
7	Tech. Expectancies	13.34	2.39
8	Approach-oriented Goals	20.42	8.14
9	Avoidant-oriented Goals	11.78	7.23
10	Mastery Goals	27.42	6.57
11	Negative Affect	2.48	2.49
12	Number of Setbacks	1.48	1.40
13	Perceived Ease of Use	18.34	4.48
14	Perceived Usefulness	17.27	5.22
15	Number of Notes	5.85	4.81

Table 5.
Intercorrelations of Study 2 Variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Tech. Usage														
2	Res.	.12													
3	Cond.	-.06	-.10												
4	Susp.	-.03	.05	-.25**											
5	T1 IT	.13	.23*	.34***	.23**										
6	T2 IT	.01	.15	.18*	.24**	.73***									
7	Expect.	.16	.26**	-.03	.06	.42***	.39***								
8	Appr.	.22*	.12	.12	-.15	.02	-.07	-.11							
9	Avoid.	.20*	-.38***	-.05	-.03	-.29**	-.40***	-.36***	.18						
10	Mastery	.32***	.28**	.06	.07	.23*	.22*	.21*	.47***	-.12					
11	Neg. Affect	-.13	-.24**	.08	-.18	-.20*	-.24**	-.26**	.01	.24**	-.31***				
12	Setbacks	-.18*	-.08	-.20*	.01	-.16	-.17	-.03	-.18	.04	-.37***	.39***			
13	Ease of Use	.16	.12	.01	.10	.14	.21*	.13	.19*	.06	.43***	-.31***	-.56***		
14	Useful.	.27**	.07	-.03	.09	.01	.12	.06	.22*	.23*	.51***	-.22*	-.45***	.69***	
15	Notes	-.01	-.09	-.05	.13	.02	.09	-.03	-.04	.23*	.07	-.14	-.07	.09	.24**

* $p<.05$, ** $p<.01$, *** $p<.001$

Manipulation check. An ANCOVA including suspicion and resilience as covariates indicated that the manipulation was effective in shifting implicit theories ($F(1,116)=30.59$, $p<.001$, $\eta^2=.18$), with participants in the entity condition exhibiting a more entity theory ($M=16.08$) than participants in the incremental condition ($M=20.83$). Implicit theories were also influenced by suspicion of the manipulation ($F(1,116)=17.05$, $p=<.001$, $\eta^2=.10$) and resilience

($F(1,116)=11.08$, $p=.001$, $\eta^2=.06$). Participants exhibiting any suspicion of the manipulation ($M=21.32$), as well as participants with a greater than median resilience score ($M=20.16$) had a more incremental theory than participants not exhibiting suspicion ($M=18.20$) or having a less than median resilience score ($M=17.02$).

Path analysis. See Figure 5 for a visual representation of the following analyses and relationships between variables. As in Study 1, each regression equation in this path analysis included all variables mentioned and any possible interaction terms as suggested by correlations (see Table 5), and was calculated using conditional process analysis (Hayes, 2013). Only significant interactions have been reported. Confidence intervals were bootstrap-generated using 5,000 samples from the original dataset.

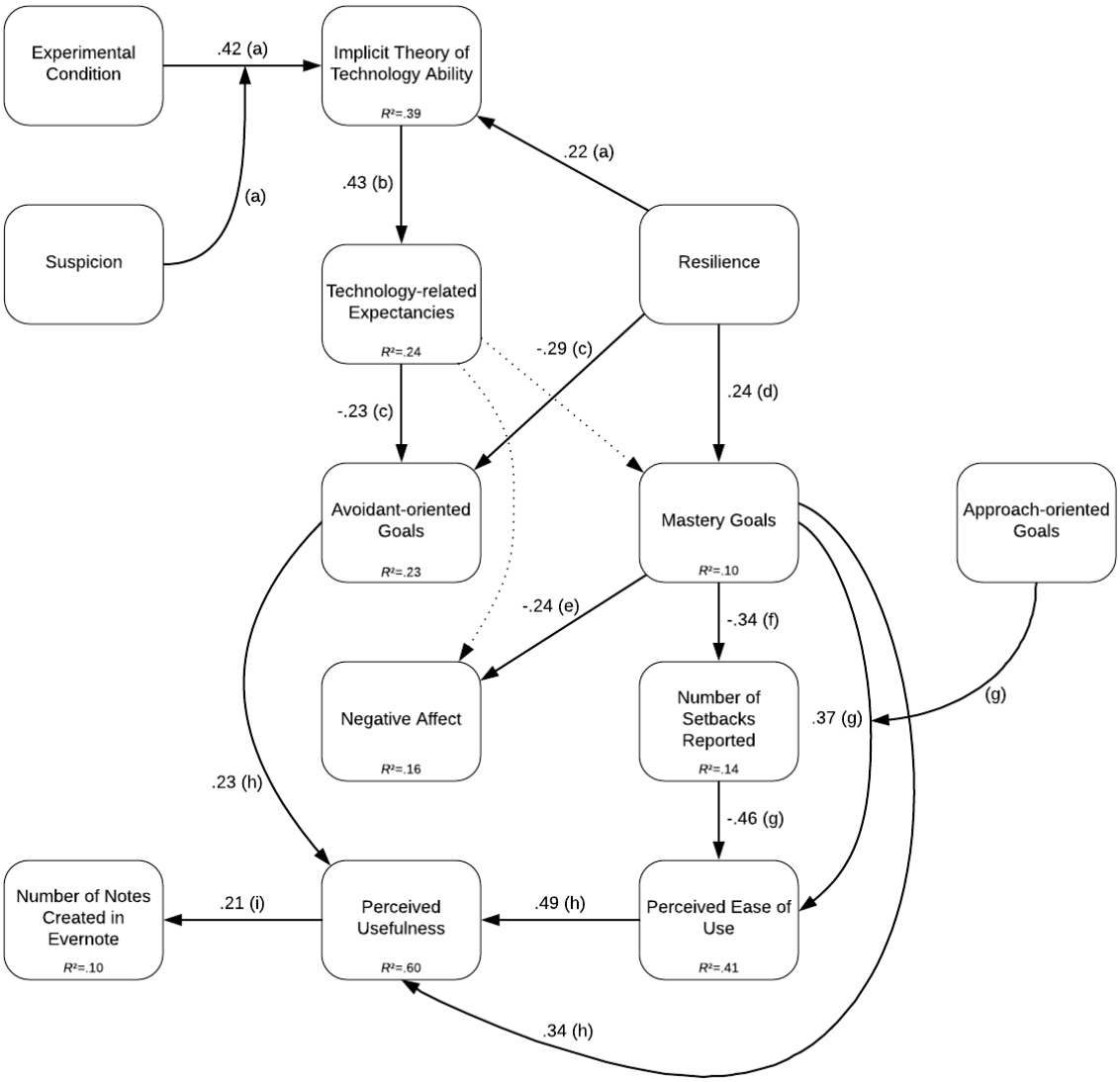

Figure 5. Study 2 path analysis model, dotted lines indicating paths rendered nonsignificant when resilience is included, link labels indicating subcomponent analyses

Implicit theories. *(a).* Implicit theories of technology ability were affected by experimental condition (β=.42, $t(119)=5.55$, $p<.001$, 95% CI [.27, .58]), and resilience (β=.22, $t(119)=2.99$, $p=.004$, 95% CI [.08, .37]) when controlling for breadth of technology usage, $F(6,113)=12.18$, $p<.001$, $R^2=.39$. Participants in the incremental implicit theory condition, and participants who were more resilient had a more incremental implicit theory. There was a

significant interaction of experimental condition and suspicion ($t(119)=-3.84$, $p<.001$), such that the manipulation effect on implicit theory for participants in the entity condition became nonsignificant with clear suspicion (see Figure 6).

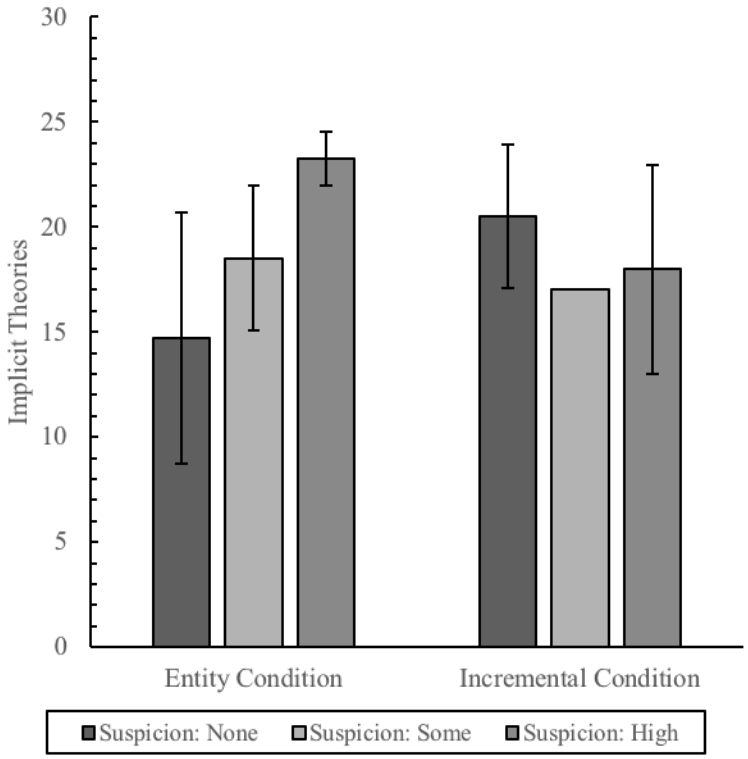

Figure 6. Manipulation by suspicion interaction on implicit theory at T1, bars indicating standard deviations, suspicion group sizes as follows: none, $n=101$; some, $n=3$; high, $n=16$

Implicit theory at T1 significantly predicted implicit theory at T2 ($\beta=.72$, $t(119)=9.58$, $p<.001$, 95% CI [.57, .86]) when controlling for suspicion and resilience, $F(5,114)=28.62$, $p<.001$, $R^2=.56$. Suspicion of the manipulation significantly moderated the mediated effect of the manipulation on implicit theory at T2 ($t(119)=-2.18$, $p=.031$), such that the effect was nonsignificant for participants in the entity condition with higher suspicion (see Figure 7 and Table 2).

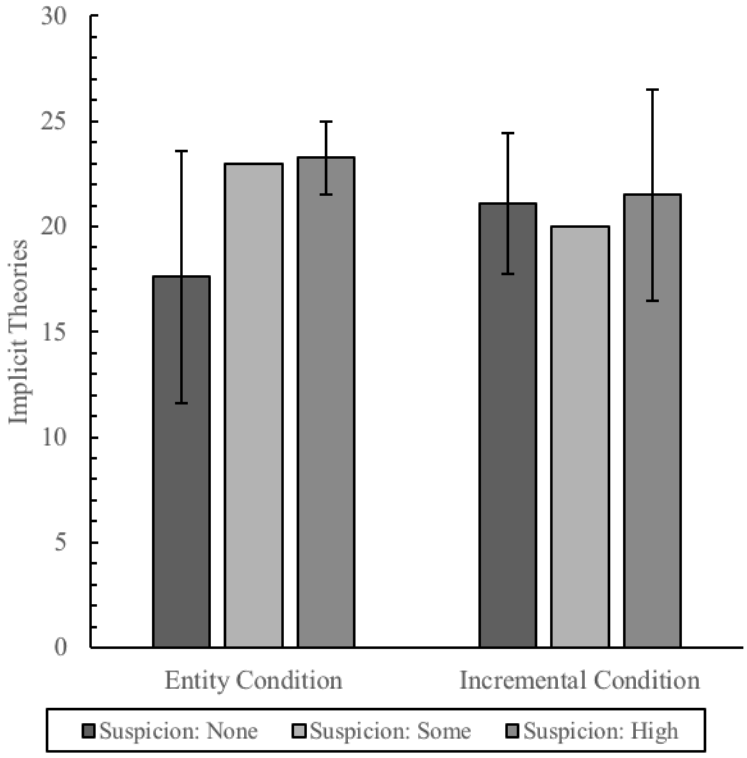

Figure 7. Manipulation by suspicion interaction on implicit theory at T2, bars indicating standard deviations, suspicion group sizes as follows: none, *n*=101; some, *n*=3; high, *n*=16

As in Study 1, the results of this and all following analyses were also checked using a subset of the sample that excluded participants with clear suspicion of the manipulation. In that subset, the effect of the manipulation on implicit theory grew stronger, and the manipulation by suspicion interaction became nonsignificant. Otherwise, the overall pattern of effects was similar, with most beta weights and R^2 values within ±.05 of those reported here, and none lost significance or changed direction. Thus, we have included the full sample in all further analyses.

Expectancies. *(b).* Technology-related expectancies were affected by implicit theory (β=.43, $t(119)=4.64$, $p<.001$, 95% CI [.25, .61]) when controlling for resilience and breadth of technology usage, $F(5,114)=7.10$, $p<.001$, $R^2=.24$. Participants with a more incremental implicit theory had higher technology-related expectancies. The effect of experimental condition on

technology-related expectancies was fully mediated by implicit theory (indirect effect=.18, 95% CI [.09, .31]; see Table 2).

Goals. *(c).* Avoidant-oriented goals were affected by technology-related expectancies (β=-.23, t(119)=-2.53, p=.013, 95% CI [-.41, -.05]) and resilience (β=-.29, t(119)=-3.39, p=.001, 95% CI [-.46, -.12]), F(3,116)=11.62, p<.001, R^2=.23. People with higher levels of technology-related expectancies and people with higher levels of resilience had fewer avoidant-oriented goals. The effect of implicit theory was fully mediated by technology-related expectancies (indirect effect=-.09, 95% CI [-.20, -.02]; see Table 2).

(d). Technology-related expectancies predicted mastery goals (β=.21, 95% CI [.03, .39]) in a simple linear regression (F(1,118)=5.60, p=.020, R^2=.05), such that people with higher levels of technology-related expectancies had more mastery goals. When the effect of resilience (β=.23, t(119)=2.33, p=.021, 95% CI [.04, .44]) was included in the regression equation, however, the effect of technology-related expectancies became nonsignificant, F(3,116)=4.33, p=.006, R^2=.10. People with higher levels of resilience had more mastery goals.

Response to setbacks. *(e).* Similarly, negative affect was affected by mastery goals (β=-.27, t(119)=-3.04, p=.003, 95% CI [-.44, -.09]) and technology-related expectancies (β=.-.20, t(119)=-2.24, p=.027, 95% CI [-.37, -.02]), with an indirect mediated effect of technology-related expectancies by mastery goals (indirect effect=-.06, 95% CI [-.13, -.01]), F(2,117)=9.01, p=<.001, R^2=.13. People with more mastery goals and people with higher levels of technology-related expectancies had lower levels of negative affect. However, when the model controlled for resilience and avoidant-oriented goals, technology-related expectancies became a nonsignificant

predictor, leaving only the effect of mastery goals (β=-.24, $t(119)=-2.66$, $p=.009$, 95% CI [-.41, -.06]), $F(4,115)=5.51$, $p<.001$, $R^2=.16$.

(f). The number of setbacks reported was influenced by mastery goals (β=-.34, $t(119)=-3.81$, $p<.001$, 95% CI [-.52, -.17]) when controlling for breadth of technology usage, $F(2,117)=9.58$, $p<.001$, $R^2=.14$. People with more mastery goals reported fewer setbacks.

Adoption outcomes. *(g).* Perceived ease of use was affected by number of setbacks (β=-.46, $t(119)=-5.64$, $p<.001$, 95% CI [-.63, -.30]) and mastery goals (β=.37, $t(119)=3.56$, $p<.001$, 95% CI [.16, .57]) when controlling for approach-oriented goals, negative affect, and breadth of technology usage, $F(6,113)=13.04$, $p<.001$, $R^2=.41$. The number of reported setbacks partially mediated the effect of mastery goals on perceived ease of use (indirect effect=.12, 95% CI [.02, .23]; see Table 2), and the direct effect was moderated by approach-oriented goals ($t(119)=2.44$, $p=.016$), such that it grew stronger with more approach-oriented goals (see Figure 8). People reporting fewer setbacks, and people with more mastery goals rated Evernote as easier to use.

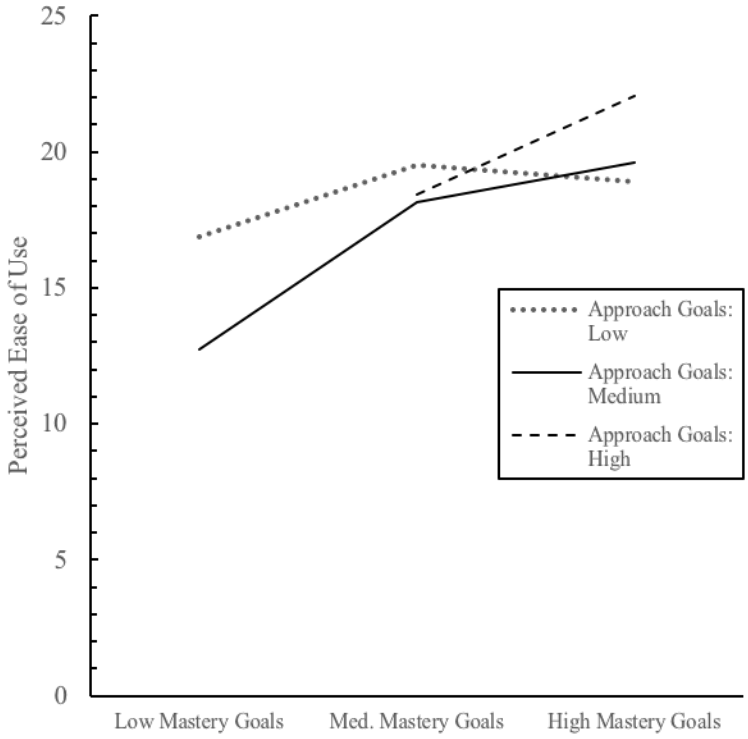

Figure 8. Mastery by approach-oriented goals interaction on perceived ease of use, produced using tertile-split mastery and approach-oriented goal scores

(h). Perceived usefulness was affected by perceived ease of use (β=.49, $t(119)=6.28$, $p<.001$, 95% CI [.33, .64]), mastery goals (β=.34, $t(119)=4.22$, $p<.001$, 95% CI [.18, .50]), and avoidant-oriented goals (β=.26, $t(119)=3.98$, $p<.001$, 95% CI [.13, .39]) when controlling for approach-oriented goals, breadth of technology usage, and number of setbacks reported, $F(7,112)=23.86$, $p<.001$, $R^2=.60$. Perceived ease of use partially mediated the effect of mastery goals on perceived usefulness (indirect effect=.22, 95% CI [.11, .34]; see Table 2). People who perceived Evernote as easier to use, people with more mastery goals, and people with more avoidant-oriented goals perceived Evernote as more useful.

(i). The number of notes created was affected by perceived usefulness (β=.21, $t(119)=2.34$, $p=.021$, 95% CI [.03, .39]) when controlling for avoidant-oriented goals,

$F(3,116)=4.35$, $p=.006$, $R^2=.10$. People who perceived Evernote as more useful created more notes.

Discussion

In support of our theoretical model, we observed a path from implicit theories to adoption through technology-related expectancies and avoidant-oriented goals. We did not, however, observe a mediated effect of technology-related expectancies on perceived usefulness via avoidant-oriented goals, nor were there any persistent observed relationships with responses to setbacks when resilience was included in the regression models, although they did appear while resilience was left out. Thus, resilience emerged as a stronger antecedent in this study than in Study 1.

We did not expect that more avoidant-oriented goals would lead to increased perceived usefulness, rather, the opposite. This may be due in part to the Mechanical Turk context, in which workers must carefully provide quality work or else risk having their submissions rejected without pay. Nevertheless, participants were explicitly instructed to answer all post-task questions honestly, and that compensation would not be affected.

Approach-oriented goals were, for the most part, unrelated both to our predictors and to our outcomes; to an extent, this is consistent with the SOMA model, which suggests that incremental and entity theorists are equally likely to set such goals (Burnette, et al., 2013). On the other hand, the effect of mastery goals was particularly strong, having both direct and indirect effects on perceived ease of use and perceived usefulness. The only observable influence of approach-oriented goals was to amplify the effect of mastery goals on perceived ease of use.

We sought to measure actual usage rather than intentions in this study, observing that ratings of perceived usefulness had a small effect on the number of notes created. This usage outcome was self-reported rather than independently verified. As noted above, however, participants were encouraged to answer honestly, even if they failed to use Evernote consistently during the week between T1 and T2. We therefore have no reason to doubt the veracity of self-reported usage.

These results provide support for our model's generalizability. Although implicit theories were manipulated, and elements of the task were controlled, the task itself was ecologically valid and similar to a common situation faced by practitioners and the users they serve: seeking to promote adoption of an unfamiliar app. Some elements controlled in Study 1, such as the type and number of setbacks encountered, were not controlled in this study. Thus, the overall similar pattern of results in both studies suggests the results are externally valid.

GENERAL DISCUSSION

Taken together, these studies provide valuable information about how implicit theories of technology ability affect expectancies, goals, and responses to setbacks, and especially, how those effects vary in differing contexts. The contexts of the two studies were, indeed, opposite in many ways. The first was a lab experiment studying the immediate effects of a manipulation on a familiar, general interest application. The second was a field experiment which examined the effects of the same manipulation over one week using an unfamiliar, niche-purpose application. In the first, we controlled the setbacks that participants face, and measured their subsequent affect and perceptions of the system. In the second, we allowed participants to encounter whatever issues may arise, and assessed their number, affective consequences, and relationship

to actual usage. Because the two studies used different measures of constructs within our theoretical model—namely affective response, adoption and its immediate antecedents—they provide converging evidence that the observed effects more likely reflect the relationships of the underlying constructs measured, rather than being mere artefacts of measurement.

Moreover, we have observed that implicit theories of technology ability can be shifted, at least temporarily, and that this effect may improve adoption outcomes. In both studies, however, we saw that the manipulation was primarily effective for participants in the incremental condition. In practice, this may not pose a significant problem, as practitioners would likely wish to promote only an incremental theory; nevertheless, this suggests that there may have been an issue with our entity manipulation. Future research should explore other ways to alter implicit theories. A contextual manipulation within the system to be used would be of particular use for practitioners.

One major difference between the two studies is the role played by resilience. Although resilience was a significant predictor of implicit theories in Study 1 and further moderated the influence of implicit theories on expectancies, resilience had wider-ranging effects in Study 2, even to the point of rendering nonsignificant some of our predicted relationships. Since we did not assess resilience prior to the manipulation, and resilience and implicit theories are interrelated, there is the possibility that we influenced some aspect of resilience as well. We also suspect that, as the effect of the manipulation diminished over the week in Study 2, the relative effect of resilience grew stronger, as compared with the one-off lab context of Study 1. Finally, it may also be the case that resilience is a more important trait in unfamiliar contexts, or in contexts

requiring people to learn systems for specific, personal purposes rather than general usage. These competing possible explanations should be further examined in future studies.

Applications

We believe that these results may be applied to practical adoption problems like the ones that motivated this research. We offer here two brief examples. A major focus of human factors research today is improving the quality of older adults' lives through better system design. Older adults, who comprise an annually-growing proportion of the US population, face unique challenges in navigating technological tasks due to age-related decrements (Fisk et al., 2009). Interactions with technology are increasingly unavoidable. Furthermore, for older adults to benefit from systems developed to improve their quality of life, they must consistently use those systems.

Another major avenue of research is the development of effective online education systems, motivated both by their convenient availability, and concurrent economic forces: more students seek advanced degrees, and more institutions have fewer resources to meet that demand. The attrition rate for Massive Open Online Courses (MOOCs), one proposed solution, is unacceptably high, for example (Coffrin, Corrin, de Barba, & Kennedy, 2014).

Although the factors influencing adoption in these examples are complex and multifaceted, they share certain similarities with the contexts of these studies. In each case, the system may be complex, and unfamiliar users are likely to encounter setbacks while learning to use it. An implicit theory intervention may serve to ameliorate the challenges that users face and improve adoption in these contexts.

REFERENCES

Anderson, M. (2015). *Technology device ownership, 2015*. Pew Research Center.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*, 191–215.

Beal, G. M., & Bohlen, J. M. (1957). *The diffusion process*. Agricultural Experiment Station, Iowa State College.

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*, 246–263.

Brooke, J. (1996). SUS: A quick and dirty usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & I. L. McClelland (Eds.), *Usability evaluation in industry* (189–194). Bristol, PA: Taylor & Francis.

Brooke, J. (2013). SUS: A retrospective. *Journal of Usability Studies*, *8*, 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. (2011). 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*, 655–701.

Burnette, J. L., Pollack, J. M., & Hoyt, C. L. (2010). Individual differences in implicit theories of leadership ability and self-efficacy: Predicting responses to stereotype threat. *Journal of Leadership Studies*, *3*(4), 46–56.

Coffrin, C., Corrin, L., de Barba, P., & Kennedy, G. (2014, March). Visualizing patterns of student engagement and performance in MOOCs. In *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge*. ACM.

Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly*, *19*, 189–211.

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

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, *41*, 1040–1048.

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

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

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

Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories: Elaboration and extension of the model. *Psychological Inquiry*, *6*, 322-333.

Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological Inquiry*, *6*, 267–285.

Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72,* 218–232.

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.

Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, *26*, 331–362.

Hayes, A. F. (2013). *Introduction to mediation, moderation and conditional process analysis: A regression-based approach.* New York, NY. The Guilford Press.

Kray, L. J., & Haselhuhn, M. P. (2007). Implicit negotiation beliefs and performance: experimental and longitudinal evidence. *Journal of Personality and Social Psychology*, *93*, 49–64.

Lee, Y. H., Heeter, C., Magerko, B., & Medler, B. (2012). Gaming mindsets: Implicit theories in serious game learning. *Cyberpsychology, Behavior, and Social Networking*, *15*, 190–194.

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*, 819–825.

Norman, D. (2013). *The design of everyday things: Revised and expanded edition*. Basic Books (AZ).

Norman, D. A. & Draper, S. W. (1986). User centered system design: New perspectives on human-computer interaction. Hillsdale, NJ: L. Erlbaum Associates.

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

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. 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.

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*, 899-904.

Smith, B. W., Dalen, J., Wiggins, K., Tooley, E., Christopher, P., & Bernard, J. (2008). The Brief Resilience Scale: assessing the ability to bounce back. *International Journal of Behavioral Medicine*, *15*, 194-200.

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*, 1453-1471.

Thompson, E. R. (2007). Development and validation of an internationally reliable short-form of the positive and negative affect schedule (PANAS). *Journal of Cross-Cultural Psychology*, *38*, 227-242.

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

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly*, *36*, 157-178.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68-81.

APPENDICES

Appendix A
Experimental Manipulation Articles

1. Incremental Condition

Headline: Technological competence can be improved
Chris K. struggled with technology beginning in elementary school when she didn't seem to pick up computer skills at the same rate as her classmates. But, in high school, Chris began doing her own research and learning what devices she would enjoy and would work best for her. As an adult, Chris now maintains her skills by following the latest trends in the tech industry, regularly upgrading her devices, and taking classes or watching YouTube instructional videos to learn new skills. Is Chris's story the norm or the exception? Research suggests that Chris's story is likely an example of the norm.

Technology ability can change with the right strategies.
Researchers at Massachusetts Institute of Technology's Humans and Computers Lab (HCL) were interested in characteristics of technology ability such as enjoyment and motivation, and how they develop over an individual's lifetime. To investigate this topic, over eight hundred individuals were identified at birth and extensive data on them was collected throughout the next thirty years, through individual and family medical histories, observations and interviews.

Dr. Lawrence Rescorla, director of HCL, reported the findings: "Technology skills are changeable and can be improved. In fact, enjoying learning about technology is responsible for nearly 90 percent of program adherence in our studies."

NIH psychologist Dr. Paul Medin drew similar conclusions from six longitudinal studies with varied samples. Dr. Medin found that "No one's technology ability is permanent. For some people, finding motivation or a more usable device is needed to bring about changes."

How does tech ability change?
Researchers, like Dr. Russell Kelly, a bio-geneticist at UCLA, echoed similar conclusions. "With enough drive, and by choosing enjoyable activities, people can develop and improve their ability to become competent tech users," Dr. Kelly said.

Possibly the most notable example demonstrating the ability to change one's ability to use technology comes from the 2001 Harvard Childhood Exposure to Technology Study, an intervention run by Dr. Richard Clark Cabot. Designed to serve the needs of 250 youngsters who were identified by school officials and parents as below average in computer and technology skills, the five-year intervention included psychotherapy, skills counseling, and regular visits from caseworkers.

The program's results were convincing: overall technology ability is fluid, not fixed. Compared to other "at risk" youth who did not participate in the program, intervention participants showed dramatic improvements in their ability to improve their technology ability. In fact, most of them continued to improve skills up to ten years later, indicating that an individual's technology ability can be changed and maintained when utilizing the right strategies.

Conclusions
To conclude, research findings from a range of studies, including large-scale longitudinal studies, rigorous experiments, intervention programs, twin studies, and case study analyses, converge to one major conclusion: **Technology ability and habits seem changeable—these things are within your control.**

2. Entity Condition

Headline: Technology ability, like plaster, is pretty stable over time
Chris K. struggled with technology beginning in elementary school when she didn't seem to pick up computer skills at the same rate as her classmates. Now in adulthood, Chris considers herself exceptionally plagued by bugs, errors, and frustrations, despite suggestions by friends and family. Research suggests that Chris's story is likely an example of the norm.

Technology ability is pretty stable over time
Researchers at the Massachusetts Institute of Technology's Humans and Computers Lab (HCL) were interested in characteristics of technology usage, such as enjoyment and motivation, and how they develop over an individual's lifetime. To investigate this topic, over eight hundred individuals were identified at birth and extensive data on them was collected throughout the next thirty years, through individual and family medical histories, observations and interviews.

Dr. Lawrence Rescorla, director of HCL, reported the findings: "Technology ability seems to be a fixed entity, remaining fairly stable over a person's lifetime. Surprisingly, nearly 90% of an individual's technology ability is determined by genetic factors."

NIH psychologist Dr. Paul Medin drew similar conclusions from six longitudinal studies with varied samples. He stated that "in most people, by the age of eleven, technology ability (and often technology habits as well) has set like plaster and will never soften again."

These studies, together with other nationally recognized scientific reports, have made clear the fact that people's technology ability is determined at an early age, and that it remains stable thereafter.

Why doesn't technology ability change?
Researchers, like Dr. Russell Kelly, a bio-geneticist at UCLA, echoed similar conclusions. "Regardless of one's enthusiasm or the amount of external help they receive, people's technology ability does not seem able to improve that much," Dr. Kelly said. Possibly the most notable example demonstrating the fixed nature of technology ability comes from the 2001 Harvard Childhood Exposure to Technology Study, an intervention run by Dr. Richard Clark Cabot. Designed to serve the needs of 250 youngsters who were identified as below average in computer and technology skills, the five-year intervention included psychotherapy, skills counseling, and regular visits from caseworkers.

The program's results are convincing: overall technology ability is an issue of genetics, not effort. Compared to other youth who did not participate in the program, intervention participants did not improve their aptitude. In fact, most of the children in the study continued to

experience difficulty in technology curricula up to ten years later, indicating that an individual's ability and technology habits are likely to remain stable regardless of intervention.

Conclusions

To conclude, research findings from a range of studies, including large-scale longitudinal studies, rigorous experiments, intervention programs, twin studies, and case study analyses, converge to one major conclusion: **Technology ability and habits seem to be fixed and difficult to improve: these things are beyond personal control.**

Appendix B
Items for Constructs

Measure	Items	Response
Brief Resilience Scale	I tend to bounce back quickly after hard times. I have a hard time making it through stressful events. It does not take me long to recover from a stressful event. It is hard for me to snap back when something bad happens. I usually come through difficult times with little trouble. I tend to take a long time to get over set-backs in my life.	5-point "Strongly disagree" to "Strongly agree"
Computer Usage Questionnaire	How often do you perform the following activities? Getting directions or local recommendations Checking weather Reading, watching videos, listening (music, audiobooks, podcasts) Writing emails Text messaging, chatting, or videochatting Searching the Internet Social networking Playing games	5-point "Never" to "Very often"
Prior Excel experience	Please rate your own ability to use Microsoft Excel or similar spreadsheet software.	
Technology-related Expectancies	I can usually complete technological tasks… …if there is no one around to tell me what to do as I go. …if I can search or use a help function for assistance. …if someone shows me how to do it first. …if I've used similar systems to do the same task.	
Abbreviated Positive and Negative Affect Schedule	Right now, to what extent do you feel: Upset Hostile Alert Ashamed Inspired Nervous Determined Attentive Afraid Active	5-point "Very slightly" to "Very often"

Measure	Items	Response
System Usability Scale	I think that I would like to use this system frequently. I found the system unnecessarily complex. I thought the system was easy to use. I think that I would need the support of a technical person to be able to use this system. I found the various functions in this system were well integrated. I thought there was too much inconsistency in this system. I would imagine that most people would learn to use this system very quickly. I found the system very cumbersome to use. I felt very confident using the system. I needed to learn a lot of things before I could get going with this system.	5-point "Strongly agree" to "Strongly disagree"
Net Promoter Score	How likely is it that you would recommend this system to a friend or colleague?	10-point
Evernote Setbacks	I wasn't sure where to go for help. I wasn't sure how to integrate it into my routine. It didn't do what I expected it to do. It didn't have the feature I wanted. There wasn't enough explanation within the app. I was confused by the design of the app. I was overwhelmed with the features. I wasn't sure how the features worked together. I didn't know where to begin. No one I knew was able or willing to help me. I got too busy to learn how to use it. I ran into a problem, and couldn't figure out how to solve it. Other, please specify	Select from list
Perceived Ease of Use	My interaction with Evernote is clear and understandable. Interacting with Evernote does not require a lot of my mental effort. I find Evernote to be easy to use. I find it easy to get Evernote to do what I want it to do.	7-point
Perceived Usefulness	Using Evernote improves my performance. Using Evernote increases my productivity. Using Evernote enhances my effectiveness. I find Evernote to be useful.	7-point

Appendix C
Factor Loadings for Technology-related Goals

Item	1 **Mastery goals** α=.88	2 **Approach-oriented goals** α=.85	3 **Avoidant-oriented goals** α=.81	**Item-rest Correlation**
I want to learn as much as possible about technology.	.85			.73
It is important for me to understand new technologies as thoroughly as possible.	.71			.71
I hope to have gained a broader and deeper knowledge of current technology when I am done with this study.	.82			.55
I desire to completely master new technologies.	.74			.73
I prefer new technologies that arouse my curiosity, even if they are difficult to learn.	.75			.70
I prefer new technologies that really challenge me so I can learn new things.	.82			.75
It is important to me to keep up with technology more than my peers.		.73		.70
My goal in learning about technology is to use it more easily than my peers.		.58		.60
I am striving to demonstrate my ability relative to my peers.		.93		.72
I am motivated by the thought of outperforming my peers.		.81		.67
It is important to me to do well compared to others.		.79		.60
I want my family, friends, advisors, and others to see how skilled I am with technology.		.45		.52
When using a new technology, I often think to myself, "What if I mess up?"			.86	.75
I worry about the possibility of messing things up badly when I use new technology.			.87	.74
My fear of performing poorly with new technologies is often what motivates me to learn.			.71	.53
I just want to avoid making mistakes with new technology.			.70	.47
I'm afraid that if I ask a peer a "dumb" question about technology, they might not think I'm very smart.			.61	.55
I wish that I didn't need to learn new technology.*	-.60			.43

* Because this item loaded on a different factor than intended, it was dropped from the scale and not used in analyses.