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A Personal Resource for Technology Interaction: Development and Validation of the Affinity for Technology Interaction (ATI) Scale

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ABSTRACT

Successful coping with technology is relevant for mastering daily life. Based on related conceptions, we propose affinity for technology interaction (ATI), defined as the tendency to actively engage in intensive technology interaction, as a key personal resource for coping with technology. We present the 9-item ATI scale, an economical unidimensional scale that assesses ATI as an interaction style rooted in the construct need for cognition (NFC). Results of multiple studies ($n > 1500$) showed that the scale achieves good to excellent reliability, exhibits expected moderate to high correlations with geekism, technology enthusiasm, NFC, self-reported success in technical problem-solving and technical system learning success, and also with usage of technical systems. Further, correlations of ATI with the Big Five personality dimensions were weak at most. Based on the results, the ATI scale appears to be a promising tool for research applications such as the characterization of user diversity in system usability tests and the construction of general models of user-technology interaction.

1. Introduction

Daily life is increasingly pervaded with digital technology. Hence, successful coping with technology is increasingly important in order to master daily life. System designers usually address this challenge by aiming for user-friendly designs (i.e., facilitating coping, providing coping resources within the system). Effects of these efforts are then tested in usability tests or subjective assessments of user acceptance, preferences, user satisfaction or user experience. However, as Lewin (1939) puts it: $B = f\ (P \times E)$. Behavior is a function of the person and environment. Hence, coping with technology is a function of personal resources and system resources (i.e., to what extent systems facilitate usage). Consequently, quantifying users' personal resources is relevant when examining how system designs relate to user behavior and user experience (see e.g., Czaja & Sharit, 1993; Kortum & Owald, 2017).

From an analytical standpoint, the influence of personal resources on successful coping with technology is twofold. First, the higher the skills and knowledge regarding interaction with specific systems, the easier it is to cope with similar new systems. Second, users' personality characteristics also play an important role to the extent that they manifest in general interaction styles. A key dimension of user personality is the way people approach (new) technical systems. That is, users' affinity for technology interaction (ATI), meaning whether users tend to actively approach interaction with technical systems or, rather, tend to avoid intensive interaction with new systems. Hence, ATI can be viewed as a key personal resource for technology interaction, and quantifying users' ATI is therefore relevant for research and development in the field of user-technology interaction.

While first scales assessing constructs closely related to ATI have been proposed in recent years (Karrer, Glaser, Clemens, & Bruder, 2009; Schmettow & Drees, 2014), there is still a need for a highly economical and reliable unidimensional scale that is suitable for differentiating between users across the whole range of the ATI trait and specifically focused on ATI as a general interaction style in dealing with technology. Further, we believe it is important to root ATI in an established psychological construct. Viewing technology interaction as a type of problem-solving task (e.g., parallel to Beier, 1999) the construct need for cognition (NFC; Cacioppo & Petty, 1982) appears particularly well suited to ground ATI theoretically (see also Schmettow, Noordzij, & Mundt, 2013). NFC denotes that individuals differ regarding their tendency to engage in cognitive activities (Cacioppo & Petty, 1982; Cacioppo, Petty, Feinstein, & Jarvis, 1996). Actively exploring new systems also needs a tendency to cognitively engage with the systems. Hence, we argue that ATI should be conceptualized in close relationship to NFC (in line with Schmettow & Drees, 2014).

The objective of the present research was to develop and validate a new scale to assess ATI. To this end, we integrated and advanced previous notions related to ATI and developed

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a highly economical questionnaire scale grounded in the established psychological construct NFC. We tested the scale in multiple studies (n > 1500), assessing its dimensionality, reliability, and indicators of scale validity. We also examined the distribution of ATI values in different samples and differences in ATI related to gender, age, level of education, and study program.

2. Background

2.1. An action-regulation perspective on ATI

Viewing technology interaction from the perspective of action regulation and self-regulation (e.g., Carver & Scheier, 2000; Frese & Zapf, 1994; Hacker, 2003), technical systems constitute tools that potentially enable users to solve problems and reach goals more effectively and efficiently, that is, tools which facilitate the reduction of discrepancies between the present state of the environment and the user's desired state (i.e., referring to the feedback loop of action/self-regulation; Carver & Scheier, 2000). However, technical systems can also constitute a problematic element in the continuous loop of action regulation, for example, when people are unfamiliar with the usage of functions that could facilitate goal achievement and problem-solving.

In fact, every new technical system requires some kind of adaptation and learning by its users (e.g., because of new functions, interfaces, interaction paradigms; Hawk, 1989; Tyre & Orlikowski, 1996). That is, for successful adaptation to new systems, users need to have certain personal coping resources (Beaudry & Pinsonneault, 2005; Chen, Westman, & Eden, 2009). Existing skills for interacting with similar systems (e.g., computer literacy, Poynton, 2005; eHealth literacy, Norman & Skinner, 2006) can directly facilitate coping by reducing adaptation demands. However, general interaction styles (i.e., facets of user personality) can also drive users' adaptation to technical systems and therefore act as coping resources for successful technology interaction.

Research in the field of problem-solving (Robertson, 1985) and action/self-regulation (Carver, 2006) has long argued for the existence of individual-difference variables related to interaction styles. For example, research on intellectual styles has argued that people differ in terms of their preferred ways of information processing and problem-solving (Zhang, Sternberg, & Rayner, 2012), for instance, showing a preference for low-structured, complex tasks or high-structured, simple tasks (Zhang & Sternberg, 2005). Further, research on action-related core personality dimensions has suggested that approach vs. avoidance temperament is a fundamental dimension of personality (Elliot & Thrash, 2002, 2010), that is, whether individuals are driven more toward approaching desirable states or avoiding undesirable states. In technology interaction, this could manifest as a tendency to approach and explore new systems and functions more actively in order to enable more efficient problem-solving, versus a tendency to avoid interaction with new systems to prevent experiencing problems with technical systems. Finally, a personality variable related to problem-solving (Nair & Ramnarayan, 2000), intellectual styles (Claxton & McIntyre, 1994), and approach temperament (Fleischhauer et al., 2010) that has stimulated a particular high amount of applied research in recent years is NFC (Cacioppo & Petty, 1982). NFC describes the intrinsic motivation to engage in cognitively demanding tasks (Cacioppo et al., 1996; Fleischhauer et al., 2010). Thus, users with a high NFC enjoy thinking and exploring complex ideas and systems and should therefore also tend to enjoy exploring new technical systems.

Viewing the continuous adaptation to new technical systems from the perspective of action regulation and problem-solving, a particularly relevant personality dimension appears to be users' immediate approach/avoidance of (i.e., tendency to engage in) intensive technology interaction. That is, do users rather (a) prefer to actively approach (i.e., engage in) the potentially cognitively demanding task of acquainting themselves with technical systems in detail or do they rather (b) tend to avoid intensive interaction with technical systems and prefer to continue with their habitual use, avoiding the need for a detailed preoccupation with technical systems? This individual-difference dimension is what we conceptualize as ATI.

2.2. Existing ATI-related personality scales

In recent years, personality traits that tackle individual differences in interacting with new technical systems have come into ever more intensive focus (for a review of key scales between 1982 and 2016 see e.g., Attig, Wessel, & Franke, 2017). The scales most closely related to ATI are the TAEG (Karrer et al., 2009) and the GEX (Schmettow & Drees, 2014). The 19-item TAEG (Karrer et al., 2009) broadly assesses affinity for technology on four dimensions. However, the scale hardly covers aspects of the interaction process, focusing instead on attitudes toward technology (e.g., purchase interest, general perception). The 15-item GEX (Schmettow & Drees, 2014) assesses geekism as a unidimensional domain-specific manifestation of one's NFC. Geekism is defined as "the need to explore, to understand and to tinker with computing devices" (Schmettow & Drees, 2014, p. 235) and hence characterizes the interaction process in general. However, the GEX is rooted in rather intense forms of ATI (i.e., computer enthusiasm/geeks). Further, both scales may be viewed as too long given the demand for highly economical assessment methods in usability testing and research on human–computer interaction (HCI; e.g., Cairns, 2013).

Hence, there is not yet any scale that focuses on the interaction facet of affinity for technology (i.e., interaction style) and can differentiate over the whole range of the trait—and which is also highly economical and reliable, unidimensional, and is rooted in an established psychological construct. In line with the rationale of Schmettow and Drees (2014) and supported by the various fruitful aspirations to utilize NFC in other areas of applied psychology (see below), we view NFC as the best construct for rooting the ATI scale.

2.3. The role of NFC for ATI

The systematic conception of NFC dates back to the 1950s, when it was defined as a need to structure and organize situations in meaningful ways (Cohen, Stotland, & Wolfe, 1955). Today, its modern conceptualization as the inter-individually varying, stable intrinsic motivation to engage in cognitively challenging tasks has become generally accepted (Cacioppo & Petty, 1982; Cacioppo et al., 1996; Fleischhauer et al., 2010) and has proven valuable for explaining individual performance differences in various fields of applied psychology (e.g., Elias & Loomis, 2002; Smith, Kerr, Markus, & Stasson, 2001; Sojka & Deeter-Schmelz, 2008).

NFC has been connected to the Big Five personality dimensions (McCrae & John, 1992), showing moderate correlations with openness to experience (Fleischhauer et al., 2010; Furnham & Thorne, 2013) and weak to moderate correlations with conscientiousness, extraversion, and emotional stability (Fleischhauer et al., 2010; Furnham & Thorne, 2013; Sadowski & Cogburn, 1997). However, NFC is not redundant with any of the Big Five, but conceptually autonomous (Fleischhauer et al., 2010).

Empirical relationships between NFC and human–technology interaction underline its role as a personal resource for successful interaction. For instance, NFC has been related to more intensive flow states regarding website interaction (Sicilia, Ruiz, & Munuera, 2005), lower computer anxiety (Maurer & Simonson, 1993), higher technological innovativeness (Hoffmann & Soyez, 2010), and a stronger tendency to search for more efficient problem-solving procedures when interacting with computers (Ebelhäuser, 2015; Keil, 2015).

The broad applicability of NFC in various psychological domains has recently also stimulated approaches to assess domain-specific variants of NFC (Keller, Strobel, Martin, & Preckel, 2017). In general, developing domain-specific variants of general personality scales has previously been demonstrated to be fruitful in other fields of research (e.g., Spector, 1988). Hence, developing an ATI scale in close alignment with the NFC construct appears to be a promising approach.

3. The ATI scale

3.1. Scale construction

The goal for the development of the ATI scale was to construct a highly economical unidimensional scale closely linked with NFC. Further, the scale should target ATI as an interaction style, while avoiding a focus on particular high-ATI or low-ATI groups in item construction. Thus, it should be applicable to highly heterogeneous populations.

To ground the ATI scale in the NFC construct, we first examined the 16-item German NFC short scale (Bless, Wänke, Bohner, Fellhauer, & Schwarz, 1994) for items that could be directly used in the ATI scale with minimal changes in wording (parallel to e.g., Beier, 1999; and Cohen & Waugh, 1989). Two items could be transferred directly (Items 3 and 6 of final ATI scale, see Appendix). Further, we constructed items based on our conceptual definition of ATI as users' tendency to actively engage in intensive technology interaction, which is itself linked to the NFC construct. The wording was targeted to emulate NFC items, combining wordings of action tendency and preference (e.g., "I try to," "I like to," "It is enough for me," with the last example representing a tendency towards action avoidance) with intensity of action (i.e., NFC = intensive thinking, ATI = intensive technology interaction). Specifically, the constructed items targeted diverse facets of active cognitive engagement in technology interaction (i.e., exploring and testing functions, devoting time, occupying oneself in greater detail, trying to understand systems, utilizing system capabilities). To keep the scale economical from the outset and to ensure a relevant influence of the two directly transferred NFC items on the total scale, we limited the final number of items to fewer than 10. Hence, we condensed our first self-generated item pool into seven items, including items which most closely reflected our conceptual definition of ATI and represented diverse facets of active, intensive interaction with technology. Finally, to allow for wide applicability of the scale, we introduced the term "technical system," referring to both software and hardware (see scale instructions, Appendix).

The translation of the German scale into English was conducted with the help of two native bilingual speakers (both researchers in the field of psychology). First, six independent translations were developed by the authors and student assistants. Second, the first bilingual speaker developed a translation of the scale independently. Third, the first author discussed this translation with the bilingual speaker in light of the other six translations, resulting in small changes which were verified by the bilingual speaker. Fourth, the translated scale was given to the second bilingual speaker for blind translation back into German. Fifth, this back translation was checked against the original version by the authors. Two instances were identified where the original scale and back translation were not in perfect accordance. Here, the English translation was adapted in consultation with the bilingual speakers. For the two items from the NFC scale, this process was adapted slightly, with the original item wording of the English NFC scale used as the basis for translation by the first bilingual speaker.

3.2. ATI scale

The English ATI scale and the German ATI scale are shown in the Appendix. An online version of the scale and further resources can be found at www.ati-scale.org. The ATI scale consists of nine items and uses a 6-point Likert scale from *completely disagree* to *completely agree*. When entering participants' responses in a data file for the analysis, the responses are coded as follows: *completely disagree* = 1, *largely disagree* = 2, *slightly disagree* = 3, *slightly agree* = 4, *largely agree* = 5, *completely agree* = 6. Responses to the three negatively worded items (Items 3, 6, 8) need to be reversed (6 = 1, 5 = 2, 4 = 3, 3 = 4, 2 = 5, 1 = 6). Finally, a mean score is computed over all nine items to obtain a person's ATI score (i.e., 1.0–6.0).

4. Empirical validation

4.1. Validation strategy

Five studies were conducted to examine scale dimensionality, reliability, distribution of values, and validity of the ATI scale in different samples (S1-S5): S1 was a university and social media sample, consisting of a composite sample of easily reachable groups (social media users and students in different study programs), S2 consisted of activity tracker users, S3 consisted of school students, S4 was a US American online sample, and S5 was a German quota sample. Additionally, the ATI scale was utilized in three bachelor theses on technology interaction to further assess its practical applicability.

To investigate construct validity, four approaches were followed. First, based on theoretical considerations regarding the nature of ATI we utilized three validated scales measuring personality traits positively related to ATI (NFC, GEX, TAEG subscale technology enthusiasm) to root ATI in the nomological network. Second, following empirical findings regarding ATI-related constructs, two additional scales (computer anxiety, control beliefs in dealing with technology) were utilized to further explore construct validity. Computer anxiety has been found to be negatively correlated with geekism (Stöhr, 2015) and positive computer attitudes (Coffin & MacIntyre, 1999), therefore ATI should also be negatively correlated with computer anxiety. In addition, internal control beliefs are positively related with the TAEG (Karrer et al., 2009) and to positive computer attitudes (Potosky & Bobko, 2001), therefore ATI should also be positively correlated with internal control beliefs. Third, self-constructed items assessing technical problem-solving success, technical system learning success, and device usage were utilized as self-report indicators of successful coping with technology. Following the conceptualization of ATI, moderate to strong positive correlations are hypothesized. Fourth, as indicators for discriminant validity, we examined the relationship between ATI and the Big Five. As NFC is weakly to moderately positively correlated with the Big Five facets openness to experience, conscientiousness, extraversion, and emotional stability (Fleischhauer et al., 2010; Furnham & Thorne, 2013; Sadowski & Cogburn, 1997), we also expect ATI to correlate at most weakly with these facets.

4.2. Samples and procedures

Table 1 shows key descriptive sample statistics and core ATI-scale values.

Sample 1 (S1) consisted of an opportunity sample gathered online. Participants were recruited via personal invitation in three different lectures at University of Lübeck, via a student e-mail distribution list from Chemnitz University of Technology, and via social media groups. They were not compensated for their participation. Educational level ranged from no graduation (7%), still in school/university/training (28%), vocational training or similar (28%), to university degree (38%).

Sample 2 (S2) was gathered online in the context of a study examining motivational aspects of personal quantification (Attig & Franke, 2017). Participants were all active users of activity trackers and were recruited via social media groups focusing on activity tracking, fitness, and weight loss, and were not compensated for their participation. Educational level was not assessed in this study.

Sample 3 (S3) consisted of secondary school students on a field trip to a German university (project day in computer science). All seventh-grade classes of that school participated independently of their prior interest in computer science. They were not compensated for their participation.

Sample 4 (S4) was an US American sample recruited online via Amazon Mechanical Turk (MTurk). A sample size of 300 was set as goal with a reward of #0.5, comparable to prices paid on MTurk for surveys of comparable length (~10 minutes). All users registered as living in the US could participate. Approaches suggested by Mason & Suri (2012) and Schaarschmidt, Ivens, Homscheid, and Bilo (2015) were used to increase data quality, consisting of attention checks in the survey and quality filtering prior to the main analysis. Participants were excluded if they did not complete the questionnaire, took part outside the US (IP filtering), took part twice (IP address), or failed one or both attention checks. In total, 240 participants passed the strict quality filtering. These participants had an education level ranging from less than high school (0.4%), high school graduate (40%), bachelor/master degree (55%), to higher than master (e.g., PhD; 5%).

Sample 5 (S5) was gathered with a pen-and-paper questionnaire in the inner cities of Bamberg, Bremen, Chemnitz, Essen, Flensburg, Leipzig, and Lübeck. The aim was twofold: First, to sample responses of participants from the general public apart from a pure online sample. Second, to attain a sample that closely matched the distribution of age, gender, and education level of the population.

Table 1. Sample characteristics of the five studies used for empirical validation and the three Bachelor theses.

No.	Label	N	Age (SD) range	Female: male	ATI M (SD) range	ATI Cronbach's alpha
S1	University and social media sample	300	25.87 (6.22) 16–54	77:23	4.14 (0.88) 1.33–6.00	.88
S2	Activity tracker user sample	210	29.93 (7.46) 15–61	92:8	3.97 (1.09) 1.00–6.00	.92
S3	School students sample	65	12.97 (0.73) 10–15	60:40	3.78 (0.87) 2.11–5.56	.83
S4	US sample	240	40.01 (11.93) 20–73	55:45	3.91 (0.95) 1.00–6.00	.90
S5-full	Quota sample - full	529	46.31 (18.07) 15–88	51:49	3.58 (1.09) 1.00–6.00	.89
S5-strict	Quota sample - strict (subset of S5-full)	232	48.81, (18.57) 16–87	51:49	3.61 (1.08) 1.00–5.89	.87
BT1	Activity tracker study	58	30.24 (9.94) 18–64	69:31	4.28 (1.14) 1.89–5.89	.94
BT2	Gamification study	65	37.06 (12.6) 20–77	86:14	4.23 (0.95) 2.44–6.00	.90
BT3	EcoDriving study	41	47.32 (9.49) 29–68	5:95	4.41 (0.77) 2.33–5.56	.90

Note. S1 Age: n = 299.

Participants were recruited via personal address by four student assistants. Recruitment followed a quota scheme in accordance with the distribution of age (six groups), gender (male vs. female) and educational level (academic vs. nonacademic) in the German population. Given that only gender and age could be determined visually, some groups were oversampled (i.e., demographic characteristics were assessed after ATI scale to avoid order effects). Participants were not compensated for their participation. Eighteen of the 547 original questionnaires contained missing values in demographics and/or ATI values and were removed. Corresponding to the objectives of S5, we refer to the results of this sample in two ways:

Sample 5-full (S5-full): First, we provide information about the whole sample of n = 529 participants. While providing more cases, the full sample oversamples some groups, esp. academics between 25 and 55 years (educational background: 32% education less than high school diploma, 29% high school diploma, 34% bachelor/master degree, and 5% higher than master (e.g., PhD)).

Sample 5-strict (S5-strict): Second, we refer to a subset (n = 232) of the S5 data that avoids oversampling by matching the distribution of age, gender, and educational level in the population. Given the distribution of participants over the 24 (6 × 2 × 2) cells in the matrix, a subset of 232 was the maximum size that could be drawn while strictly matching the distribution of the quota criteria in the population (i.e., age groups, gender, academic yes/no). Education level ranged from 45% less than high school diploma, 38% high school diploma, 15% bachelor/master degree, to 3% higher than master (e.g., PhD).

BT1 was gathered in an online study addressing regular users of activity trackers focusing on usage motives (Karp, 2017). Educational background was not assessed in this study.

BT2 was gathered in an online study addressing persons interested in weight loss with the aim of examining different feedback types on motivation in a diet app (Pieritz, 2017). Educational background was not assessed in this study.

BT3 was gathered in an online study addressing hybrid electric vehicle drivers with the aim of examining effects of different interface designs on perceptions of energy efficiency (Schwarze, 2017). Educational background ranged from vocational training or similar (37%) to university degree (63%).

4.3. Measures to assess construct validity

For all measures, Cronbach's alpha was interpreted according to common practice (e.g., Cripps, 2017) as poor (.5 ≤ α < .6), questionable (.6 ≤ α < .7), acceptable (.7 ≤ α < .8), good (.8 ≤ α < .9), or excellent (≥ .9). Internal consistencies of the scales are depicted in Table 2.

Constructs expected to be related to ATI according to conceptual considerations

To assess NFC, the 4-item NFC-K (Beißert, Köhler, Rempel, & Beierlein, 2015) was used. Reliability ranged from acceptable (S1) to good (S4), except S3 (secondary school students sample, scale not designed for this age group, hence related result has to be interpreted with caution). For assessing geekism, the 15-item GEX (Schmettow & Drees, 2014) was used (S1, S3, S4). Reliability was good to excellent. For assessing the facet of the 19-item TAEG (Karrer et al., 2009) most closely related to ATI, we used the 5-item subscale technology enthusiasm (S1, S3). Reliability was good.

Table 2. Internal consistencies of the validity indicators.

Variable	Cronbach's alpha S1	S3	S4
Need for cognition (NFC-K)	.72	.36	.82
Geekism (GEX)	.94	.87	.95
Technology enthusiasm (TAEG)	.84	.87	-
Computer anxiety (COMA)	.85	.63	-
Control beliefs in dealing with technology (KUT)	.84	.88	-
Technical problem solving success	.76	.82	.84
Technical system learning success	.67	.58	.78

Note. S2 was gathered in the context of a study investigating a specific research question (Attig & Franke, 2017). Therefore none of the scales were assessed. Due to the survey method used in S5, none of the scales were assessed.

Constructs expected to be related to ATI according to empirical considerations

To assess the relationship between ATI and computer anxiety, the 8-item COMA (Richter, Naumann, & Horz, 2010) was used (S1, S3). Reliability was good (S1), resp. questionable (S3). For assessing control beliefs in dealing with technology, the 8-item KUT (Beier, 1999) was applied (S1, S3). Reliability was good.

Indicators for successful coping with technology

Three self-report measures were developed to assess users' success in coping with technology. Participants rated their degree of agreement on 6-point Likert scales ranging from 1 (*completely disagree*) to 6 (*completely agree*). First, four items assessed technical problem-solving success (TPSS; S1, S3, S4): "If problems with a technical system occur, I can easily solve them on my own (e.g., by trying out, online research).", "If a problem with a technical system occurs, I often need someone else's help." (reverse coded), "If less competent people ask me for help with technical problems, I can help them most of the time.", and "If error messages occur during the use of a technical system, I always know what to do." Reliability was acceptable (S1) to good (S3, S4). Second, participants' technical system learning success (TSLS) was assessed with three items: "Learning how to use a new technical system for a specific purpose (e.g., work) comes naturally to me.", "When I try out a new technical system, I quickly find out how to use it on my own.", and "When I install a program that is new to me and has many functions on my computer, I usually need assistance for the initial training." (reverse coded). Reliability varied from poor and questionable (S1, S3) to good (S4). Third, participants of S5 were asked whether they regularly use the following technical systems (technical system usage): smartphone, tablet, computer/laptop, online-shopping, social networks, video chat, video websites, internet forums, and activity trackers. Answers were provided by checking yes or no.

Indicators for discriminant validity

The 10-item BFI-10 (Rammstedt & John, 2007) was used to assess the Big Five personality dimensions openness, conscientiousness, extraversion, agreeableness, and neuroticism

(S1, S2, S3, S4). Regarding reliability, Cronbach's alpha is not a meaningful reliability indicator for this scale given the specific scale design with the objective to broadly cover the sub-facets with two items (for details see Freudenthaler, Spinath, & Neubauer, 2008; Rammstedt & John, 2007). When computing Cronbach's alpha for informative purposes, values reached acceptability only for two dimensions and only in some samples. However, the BFI-10 is frequently used despite these issues (e.g., Lehenbauer-Baum & Fohringer, 2015; Rammstedt & Beierlein, 2014) and test-retest coefficients indicate good reliability (Rammstedt & John, 2007).

4.4. Results

Dimensionality

To examine dimensionality of the ATI scale, exploratory factor analyses were computed using parallel analysis (Horn, 1965) with the program Factor (Lorenzo-Seva & Ferrando, 2013). Optimal implementation (cf. Timmerman & Lorenzo-Seva, 2011) with 500 random correlation matrices as a permutation of sample values was used. Results indicated a clear one-factor solution (i.e., unidimensionality) in all five samples. An additional examination with scree tests (following Hayton, Allen, & Scarpello, 2004) supported these findings. Using principal factors analysis, the amount of explained variance by the single factor in S1 to S5 were 47.62% (S1), 58.56% (S2), 37.78% (S3), 54.68% (S4), 49.40% (S5-full), 47.03% (S5-strict).

Reliability and economy

Reliability of the ATI scale was assessed in all samples. Cronbach's alpha coefficients (see Table 1) ranged in the samples between .83 (S3) and .92 (S2) and between .90 and .94 in the bachelor theses on technology interaction, and can therefore be interpreted as good to excellent. Regarding economy, while depending on participant characteristics and language, most of the participants were able to complete the ATI in less than 2 min.

Validity

Table 3 shows the correlations of ATI with construct validity indicators. All effect sizes were interpreted according to Cohen (1992).

First, regarding constructs expected to be related to ATI according to conceptual considerations, ATI correlated in all samples moderately (S1, S3) to strongly (S4) positively with NFC, strongly positively with geekism (all $r \geq .63$), and moderately (S3) to strongly (S1) positively with technology enthusiasm, as expected. Second, regarding constructs expected to be related to ATI according to empirical considerations, ATI correlated moderately negatively with computer anxiety and strongly positively with control beliefs in both samples, as expected. Third, regarding self-report indicators of successful coping with technology, correlations between scales of technical problem-solving success and technical system learning success in S1 and S4 were strong and positive in both samples and for both variables, as expected. Moreover, in S5, ATI correlated moderately positively with technical system usage (S5-full: $r = .41$, $p < .001$, $n = 497$; S5-strict: $r = .36$, $p < .001$, $n = 217$). Fourth, regarding discriminant validity, correlations with BFI-10 variables (Big Five dimensions) in S1 to S4 were low (all $r < |.24|$), as expected. In sum, results of validity analyses support our hypotheses and substantiate that ATI fits in the nomological network.

Distribution of ATI values

Mean, SD, and range of the ATI scale are shown in Table 1. Based on the results of S5-strict the average ATI score in the population can be expected to be around 3.5 (i.e., center of the response scale). Further, Figure 1 depicts percentage histograms and boxplots of the ATI values in the samples. As can be seen from visual inspection, the sample from the broader public (S5) does not show any marked floor or ceiling effects. The histogram in S5-strict (Figure 1) shows that the percentages of cases in the lowest and highest categories were small (0.86% and 5.6% in the two lowest bins (i.e., between 1 and 2); 7.33% and 2.59% in the two highest (i.e., between 5 and 6)). For studies sampling potential high ATI populations (e.g., users of activity trackers as in BT1, or online workers as in S4), we find higher ATI values and relatively few people with lower ATI values.

To assess whether ATI is able to discriminate across the whole range of trait values, item difficulty and item discrimination values (according to Moosbrugger & Kelava, 2012) were calculated (see Table 4). Values of item difficulty (i.e., percentage of responses symptomatic for ATI trait) ranged on average from 46.3% (Item 8) to 65.3% (Item 2). These are satisfactory results given that moderate item difficulties (i.e., ~50%) can

Table 3. Correlations of ATI with construct validity indicators.

	r (p)			
Variable	S1	S2	S3	S4
Need for cognition (NFC-K)	.32 (<.001)	-	.36 (.004)	.54 (<.001)
Geekism (GEX)	.66 (<.001)	-	.63 (<.001)	.80 (<.001)
Technology enthusiasm (TAEG)	.62 (<.001)	-	.48 (<.001)	-
Computer anxiety (COMA)	−.41 (<.001)	-	−.43 (<.001)	-
Control beliefs in dealing with technology (KUT)	.65 (<.001)	-	.59 (<.001)	-
Technical problem solving success (TPSS)	.63 (<.001)	-	.51 (<.001)	.65 (<.001)
Technical system learning success (TSLS)	.53 (<.001)	-	.45 (<.001)	.73 (<.001)
BFI-10 Openness	.15 (.013)	.04 (.601)	−.06 (.628)	.24 (<.001)
BFI-10 Conscientiousness	−.04 (.491)	−.05 (.450)	.12 (.337)	−.05 (.449)
BFI-10 Extraversion	.07 (.267)	−.03 (.682)	.15 (.234)	.13 (.044)
BFI-10 Agreeableness	−.05 (.405)	.02 (.798)	.14 (.282)	.10 (.133)
BFI-10 Neuroticism	−.17 (.004)	−.02 (.771)	−.15 (.221)	−.20 (.002)

Note. -: not assessed in sample; S1: n = 278 (n = 288 for NFC, TAEG, n = 298 for TPSS and TSLS); S2: n = 210; S3: n = 65; S4: n = 240; due to the survey method used in S5, none of the scales were assessed.

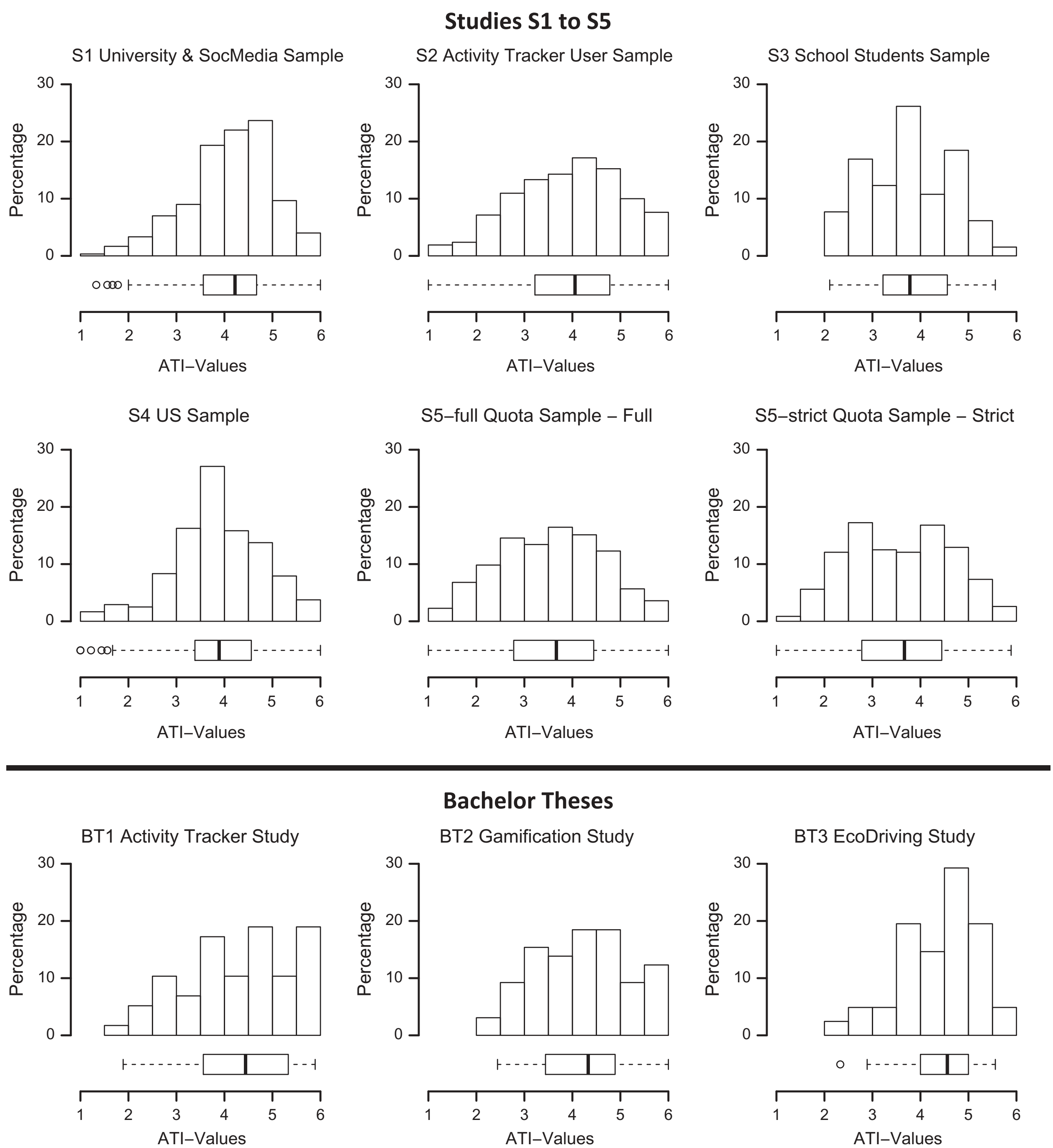

Figure 1. Percentage histograms and boxplots for mean ATI values of participants in the different samples.

differentiate best between participants with high and low trait values (Moosbrugger & Kelava, 2012). Values of item discrimination (i.e., part-whole corrected item-total correlations) ranged on average from r_{itc} = .37 (Item 3) to .76 (Item 5). These results indicate good item discrimination (Moosbrugger & Kelava, 2012), with the exception of Item 3 in S3, S4, and S5-full (r_{itc} = .27 - .32). In sum, the ATI items are able to differentiate between high- and low-ATI participants and are therefore suitable for application in the general population. However, the ATI scale does not contain items that are particularly suited to differentiate between people on the extreme low and high ends of the trait continuum.

Differences regarding gender, age, education, and study program

Significant gender differences in ATI values were found in the samples, with men having a significantly higher ATI than women (S5-strict: M_{male} = 4.13, SD_{male} = 0.94, n = 113, M_{female} = 3.13, SD_{female} = 0.98, n = 119, t(230) = 7.89, p < .001, d = 1.04, large effect). Regarding age and using Pearson product moment correlation coefficient, S5-strict showed a significant weak negative correlation between age and ATI (r = -.17, n = 232, p = .012, see Figure 2, left). The older the participants, the less pronounced their ATI (however this effect is only weak).

Table 4. Item analysis results.

	Item difficulty						Item discrimination (r_{itc})					
Item	S1	S2	S3	S4	S5	*M*	S1	S2	S3	S4	S5	*M*
1	70.6	63.0	52.4	58.2	55.7	60.0	.73	.83	.69	.71	.78	.75
2	74.2	68.8	61.6	64.4	57.4	65.3	.75	.82	.63	.77	.79	.75
3	66.0	67.6	69.0	53.2	49.5	61.1	.41	.56	.28	.27	.32	.37
4	71.4	65.6	60.0	65.4	57.1	64.5	.66	.79	.61	.73	.73	.70
5	65.0	61.0	52.6	67.8	47.9	58.9	.76	.81	.69	.79	.77	.76
6	49.8	45.4	49.6	50.0	44.2	47.8	.57	.73	.45	.71	.58	.61
7	49.0	46.4	53.2	53.6	53.7	51.2	.59	.69	.54	.76	.62	.64
8	53.0	53.0	37.0	44.6	43.7	46.3	.56	.67	.43	.66	.56	.58
9	65.0	65.0	63.6	67.0	54.1	63.0	.67	.62	.43	.74	.62	.62

Note. Item difficulty values are percentages of responses symptomatic for ATI trait of all responses; item discrimination values are part-whole corrected item-total correlations.

Note that in studies using opportunity sampling (e.g., recruiting participants for a study on technology interaction via social media, such as in BT1) this relationship is not necessarily present (see Figure 2, right), likely because of a self-selection of older participants. Also note that a quota sample is not a random sample, so similar effects are possible for gender.

In samples with educational background information (S1, S4, S5), no statistically significant relationships between educational background and ATI values were found. This includes S5-strict (using Spearman correlation coefficient, r_s = -.09, p = .186, n = 232).

Relations between ATI and study program can be examined exemplarily with psychology students and media computer science (MCS) students in S1. MCS students had significantly higher ATI values than psychology students (M_{mcs} = 4.63, SD_{mcs} = 0.65, n = 73; M_{psy} = 3.61, SD_{psy} = 0.86, n = 28, $t(39.22)$ = 5.68, p < .001, d = 1.43, large effect). However, the distribution of male and female students was not equal in each study program and gender differences might play a role as well. An ANOVA could not be calculated due to the low number of male psychology students in the sample (n = 4), however, descriptively, both male (M_{male} = 4.76, SD_{male} = 0.57, n = 54) and female (M_{female} = 4.26, SD_{female} = 0.73, n = 19) MCS students had higher ATI scores than their counterparts in psychology (M_{male} = 3.61, SD_{male} = 1.65, n = 4; M_{female} = 3.61, SD_{male} = 0.72, n = 24), with male MCS students having higher values than female MCS students.

5. General discussion

5.1. Summary of results

The objective of the present research was to develop and validate a new scale to assess the proposed construct ATI rooted in the established psychological construct NFC. Tests of the scale in multiple studies (n > 1500) showed satisfying results with regard to dimensionality, reliability, validity and distribution of ATI score values. Specifically, the results can be summarized as follows:

- Factor analyses indicated unidimensionality.
- Reliability analysis showed good to excellent internal consistency.
- Construct validity analyses support expected relationships to need for cognition, geekism, technology enthusiasm, computer anxiety, control beliefs in dealing with technology, success in technical problem-solving and technical system learning, technical system usage, and Big Five personality dimensions.
- Item analysis and descriptive statistics indicate that the ATI scale is able to differentiate between higher- and lower-ATI participants and that there are no marked floor or ceiling effects.
- Analyses of demographic variables showed a large gender effect, a small age effect, and no effect of educational background.

5.2. Implications

Based on the results of the present research we see sufficient evidence to conclude that the ATI scale is a promising tool to quantify a key dimension of users' personality in the context of technology interaction. That is, the ATI scale provides a tool to discriminate between participants based on their differing tendency to actively engage in intensive (i.e., cognitively demanding) technology interaction. First results also support the notion that this personality dimension is related to more successful coping with technology in terms of problem-solving and learning processes, hence echoing the transferability of the comprehensive research on NFC and problem-solving (Nair & Ramnarayan, 2000). Further, results of S5 give first indication that ATI could also be related to the actual use (i.e., adoption) of technical systems in everyday usage settings.

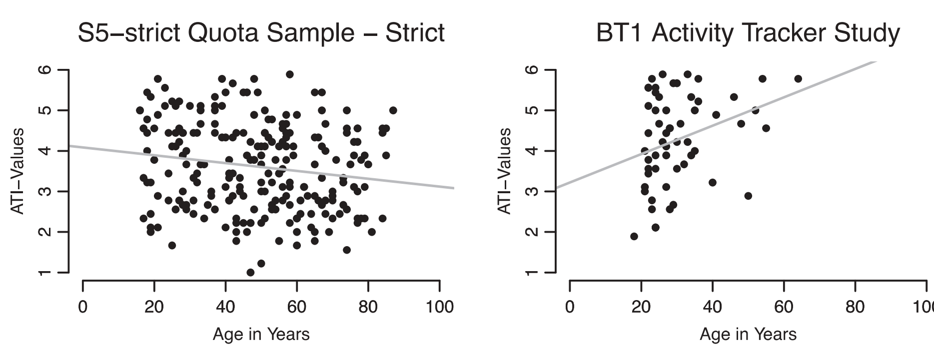

Figure 2. Scatterplots of mean ATI values and age of participants with regression line in samples S5-strict and BT1.

Important for subsequent users of the scale, the ATI scale is highly economical while providing a reliable unidimensional measure that enables easy integration in study designs in technology research (e.g., as moderator or mediator variable). Further, the ATI scale appears suited for highly diverse studies (see e.g., results of bachelor theses and application in the broader population in S5). Apart from these practical advantages, the scale also has the advantage of providing a more specific indicator for personality in technology interaction than a broad assessment of NFC or general personality factors.

Viewed from an application perspective, the ATI scale can be useful in diverse settings as the differences between low- and high-ATI individuals regarding their actual interaction with technology have important implications for research and development purposes. Example applications of the ATI scale include the following:

(1) Controlling for sampling biases: For product development (e.g., evaluating interface prototypes) and for developing models of behavior in human–technology interaction, often samples are needed that broadly cover diverse users, particularly users with substantial diversity in how they approach technology (i.e., sufficient variation of ATI). However, research on human–technology interaction might attract people with a high ATI (i.e., self-selection of high-ATI participants). Figure 2 provides a possible example for such a bias (i.e., comparing the quota sample S5-strict with the results from the bachelor thesis BT1). In BT1, with older age, people with low ATI become scarce (i.e., possible sample bias). This can pose problems for later generalizability of the results to the wider population. Hence, ATI can be used to gain more externally valid samples (e.g., by pointing out in how far certain relevant user groups are not yet represented in a sample).

(2) Identifying accessibility limitations: Some technologies might currently only appeal to groups with a high ATI who are able to overcome typical teething problems of this technology (i.e., technical problems of an early version of a product). Hence, utilizing the ATI scale can point to a limited accessibility (Shneiderman, 2000) of a certain class of products. Again, Figure 2 shows a marked lack of older users with low ATI. Thus, a lack of low ATI participants—overall, or in certain groups like older participants—might point to limited accessibility, or stated differently, a market niche.

(3) Facilitate technology adaptation: Given the disposition of high-ATI individuals to figure out systems on their own whereas low-ATI individuals need more assistance, measures supporting adaptation processes in familiarizing with new technology (e.g., trainings, tutoring systems, adaptive user interfaces) could become more efficient and effective by taking ATI into account (e.g., adapting speed of trainings or learning demands to user diversity).

In summary, the ATI scale has a variety of possible applications and might stimulate research with both a practical and a theoretical focus.

5.3. Limitations and further research

When interpreting the results of the present research, some limitations and needs for further research have to be considered. First, regarding reliability analyses, so far, only internal consistency has been examined. However, another important question is the stability of ATI values over time. Beyond the strong theoretical arguments for viewing ATI as a personality scale, such a test of temporal stability of ATI would give additional empirical support that ATI assesses a technology-related facet of personality (instead of measuring only less stable attitudes toward technology interaction). In support of our conceptualization of ATI as a personality facet, preliminary feedback from first usage of the scale indicates good test-retest reliability (S. Döbelt, personal communication, 29 November 2017). However, further studies focusing on this topic are needed.

Second, while results for construct validity are promising, further studies with indicators for criterion validity (i.e., behavioral outcome measures indicative for successful technology interaction) are necessary. The self-report indicators of the present research provided a first indication of effect size magnitude. Yet, for a precise analysis, further studies have to be conducted that examine criterion variables, which (1) are closely linked to actual behavior and (2) are not subject to confounding variables. For example, technical system usage, as assessed in S5, is a first step in this direction, as it is linked to actual behavior (fulfilling Criterion 1). However, technical system usage per se is also a function of usage opportunities and usage needs (not fully fulfilling Criterion 2).

Third, the examination of gender and age effects deserves further attention, i.e., for establishing normative data adjusted for gender and age, but also regarding generalizability. While the quota sample (S5-strict) seems to be a better representation of the population than a self-selected online sample (see Figure 2), it is not a completely random sample. As the differences in S1 indicate, the setting (study program in S1) could influence the results. However, the gender differences seem consistent across the different samples. Additionally, regarding age, results for construct validity concerning children and adolescent populations need to be replicated with age-adequate scales (e.g., Keller et al., 2016; note that for instance the BFI-10 and NFC-K were developed using adult samples, so their use for a sample of 10- to 15-year-old students and corresponding results have to be treated with caution).

6. Conclusion

Behavior is a function of person and environment. Hence, coping with technology is a function of personal resources and system resources. The present research has shown that the ATI scale is a promising tool to quantify users' personality with regard to personal resources for technology interaction. While further research is needed, the ATI scale has already demonstrated to be an economical, reliable scale that fits in the nomological network of related personality constructs. The present research also reveals several questions that deserve further attention in subsequent research to comprehensively characterize the relationship of personality to technology interaction.

To conclude, research on ATI can contribute to a general resource perspective on user-technology interaction and the development of action regulation models of user behavior.

Thus, it can contribute to advancing general models of human–technology interaction and fostering understanding of how humans adapt to technology.

Disclosure of potential conflicts of interest

All authors declare that they have no conflicts of interest.

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References

Attig, C., & Franke, T. (2017). *I track, therefore I walk – Exploring the motivational costs of wearing activity trackers in actual users*. Manuscript submitted for publication.

Attig, C., Wessel, D., & Franke, T. (2017). Assessing personality differences in human–technology interaction: An overview of key self-report scales to predict successful interaction. In C. Stephanidis (Ed.), *HCI International 2017 – posters' extended abstracts, part I, CCIS 713* (pp. 19–29). Cham, Switzerland: Springer International Publishing AG. doi:10.1007/978-3-319-58750-9_3

Beaudry, A., & Pinsonneault, A. (2005). Understanding user responses to information technology: A coping model of user adaptation. *MIS Quarterly*, *29*, 493–524. doi:10.2307/25148693

Beier, G. (1999). Kontrollüberzeugungen im Umgang mit Technik [Control beliefs in dealing with technology]. *Report Psychologie*, *9*, 684–693.

Beißert, H., Köhler, M., Rempel, M., & Beierlein, C. (2015). Kurzskala Need for Cognition NFC-K [Short scale need for cognition NFC-K]. *Zusammenstellung Sozialwissenschaftlicher Items und Skalen*. doi:10.6102/zis230

Bless, H., Wänke, M., Bohner, G., Fellhauer, R. F., & Schwarz, N. (1994). Need for cognition: A scale measuring engagement and happiness in cognitive tasks. *Zeitschrift für Sozialpsychologie*, *25*, 147–154.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, *42*, 116–131. doi:10.1037/0022-3514.42.1.116

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin*, *119*, 197–253. doi:10.1037/0033-2909.119.2.197

Cairns, P. (2013). A commentary on short questionnaires for assessing usability. *Interacting with Computers*, *25*, 312–316. doi:10.1093/iwc/iwt019

Carver, C. S. (2006). Approach, avoidance, and the self-regulation of affect and action. *Motivation and Emotion*, *30*, 105–110. doi:10.1007/s11031-006-9044-7

Carver, C. S., & Scheier, M. F. (2000). On the structure of behavioral self-regulation. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 41–84). London, UK: Academic Press. doi:10.1016/B978-012109890-2/50032-9

Chen, S., Westman, M., & Eden, D. (2009). Impact of enhanced resources on anticipatory stress and adjustment to new information technology: A field-experimental test of conservation of resources theory. *Journal of Occupational Health Psychology*, *14*, 219–230. doi:10.1037/a0015282

Claxton, R. P., & McIntyre, R. P. (1994). Empirical relationships between need for cognition and cognitive style: Implications for consumer psychology. *Psychological Reports*, *74*, 723–732. doi:10.2466/pr0.1994.74.3.723

Coffin, R. J., & MacIntyre, P. D. (1999). Motivational influences on computer-related affective states. *Computers in Human Behavior*, *15*, 549–569. doi:10.1016/S0747-5632(99)00036-9

Cohen, A. R., Stotland, E., & Wolfe, D. M. (1955). An experimental investigation of need for cognition. *The Journal of Abnormal and Social Psychology*, *51*, 291–294. doi:10.1037/h0042761

Cohen, B. A., & Waugh, G. W. (1989). Assessing computer anxiety. *Psychological Reports*, *65*, 735–738. doi:10.2466/pr0.1989.65.3.735

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*, 155–159. doi:10.1037/0033-2909.112.1.155

Cripps, B. (2017). *Psychometric testing: Critical perspectives*. Chichester, UK: John Wiley & Sons.

Czaja, S. J., & Sharit, J. (1993). Stress reactions to computer-interactive tasks as a function of task structure and individual differences. *International Journal of Human-Computer Interaction*, *5*, 1–22. doi:10.1080/10447319309526053

Ebelhäuser, J. (2015). Exploring the associations between geekism, utilitarianism and the active user paradox (Bachelor's thesis). University of Twente, Twente, Netherlands.

Elias, S. M., & Loomis, R. J. (2002). Utilizing need for cognition and perceived self-efficacy to predict academic performance. *Journal of Applied Psychology*, *32*, 1687–1702. doi:10.1111/j.1559-1816.2002.tb02770.x

Elliot, A. J., & Thrash, T. M. (2002). Approach-avoidance motivation in personality: Approach and avoidance temperaments and goals. *Journal of Personality and Social Psychology*, *82*, 804–818. doi:10.1037/0022-3514.82.5.804

Elliot, A. J., & Thrash, T. M. (2010). Approach and avoidance temperament as basic dimensions of personality. *Journal of Personality*, *78*, 865–906. doi:10.1111/j.1467-6494.2010.00636.x

Fleischhauer, M., Enge, S., Brocke, B., Ullrich, J., Strobel, A., & Strobel, A. (2010). Same or different? Clarifying the relationship of need for cognition to personality and intelligence. *Personality and Social Psychology Bulletin*, *36*, 82–96. doi:10.1177/0146167209351886

Frese, M., & Zapf, D. (1994). Action as the core of work psychology: A German approach. *In* H. C. Triandis, M. D. Dunnette, & L. M. Hough (Eds.), *Handbook of industrial and organizational psychology* (pp. 271–340). Palo Alto, CA: Consulting Psychologists Press.

Freudenthaler, H. H., Spinath, B., & Neubauer, A. C. (2008). Predicting school achievement in boys and girls. *European Journal of Personality*, *22*, 231–245. doi:10.1002/per.678

Furnham, A., & Thorne, J. D. (2013). Need for cognition – Its dimensionality and personality and intelligence correlates. *Journal of Individual Differences*, *34*, 230–240. doi:10.1027/1614-0001/a000119

Hacker, W. (2003). Action regulation theory: A practical tool for the design of modern work processes? *European Journal of Work and Organizational Psychology*, *12*, 105–130. doi:10.1080/13594320344000075

Hawk, S. R. (1989). Locus of control and computer attitude: The effect of user involvement. *Computers in Human Behavior*, *5*, 199–206. doi:10.1016/0747-5632(89)90014-9

Hayton, J. C., Allen, D. G., & Scarpello, V. (2004). Factor retention decisions in exploratory factor analysis: A tutorial on parallel analysis. *Organizational Research Methods*, *7*, 191–205. doi:10.1177/1094428104263675

Hoffmann, S., & Soyez, K. (2010). A cognitive model to predict domain-specific consumer innovativeness. *Journal of Business Research*, *63*, 778–785. doi:10.1016/j.jbusres.2009.06.007

Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrica*, *30*, 179–195. doi:10.1007/BF02289447

Karp, A. (2017). Untersuchung von Zusammenhängen zwischen Nutzungsmotivationen und Interaktionen mit Fitnessarmbändern [Examining relationships between usage motives and interactions with fitness trackers] (Bachelor's thesis). Chemnitz University of Technology, Chemnitz, Germany.

Karrer, K., Glaser, C., Clemens, C., & Bruder, C. (2009). Technikaffinität erfassen – Der Fragebogen TA-EG [Measuring affinity to technology – The questionnaire TA-EG]. *In* A. Lichtenstein, C. Stößel, & C.

Clemens (Eds.), *Der Mensch im Mittelpunkt technischer Systeme. 8. Berliner Werkstatt Mensch-Maschine-Systeme 7. bis 9. Oktober 2009* (pp. 196–201). Düsseldorf, Germany: VDI.

Keil, J. (2015). Exploring individual differences in the tendency to fall for the active user paradox (Bachelor's thesis). University of Twente, Twente, Netherlands.

Keller, U., Strobel, A., Martin, R., & Preckel, F. (2017). Domain-specificity of need for cognition among high school students. *European Journal of Psychological Assessment*, 1–10. doi:10.1027/1015-5759/a000437

Keller, U., Strobel, A., Wollschläger, R., Greiff, S., Martin, R., Vainikainen, M., & Preckel, F. (2016). A need for cognition scale for children and adolescents. Structural analysis and measurement invariance. *European Journal of Psychological Assessment*, 1–13. doi:10.1027/1015-5759/a000370

Kortum, P., & Owald, F. L. (2017). The impact of personality on the subjective assessment of usability. *International Journal of Human-Computer Interaction*, *34*, 177–186. doi:10.1080/10447318.2017.1336317

Lehenbauer-Baum, M., & Fohringer, M. (2015). Towards classification criteria for internet gaming disorder: Debunking differences between addiction and high engagement in a German sample of World of Warcraft players. *Computers in Human Behavior*, *45*, 345–351. doi:10.1016/j.chb.2014.11.098

Lewin, K. (1939). Field theory and experiment in social psychology: Concepts and methods. *American Journal of Sociology*, *44*, 868–896. doi:10.1086/218177

Lorenzo-Seva, U., & Ferrando, P. J. (2013). FACTOR 9.2: A comprehensive program for fitting exploratory and semiconfirmatory factor analysis and IRT models. *Applied Psychological Measurement*, *37*, 497–498. doi:10.1177/0146621613487794

Mason, W., & Suri, S. (2012). Conducting behavioral research on Amazon's Mechanical Turk. *Behavior Research Methods*, *44*, 1–23. doi:10.3758/s13428-011-0124-6

Maurer, M. M., & Simonson, M. R. (1993). The reduction of computer anxiety. *Journal of Research in Computing and Education*, *26*, 205–219. doi:10.1080/08886504.1993.10782087

McCrae, R. R., & John, O. P. (1992). An introduction to the five-factor model and its applications. *Journal of Personality*, *60*, 175–215. doi:10.1111/j.1467-6494.1992.tb00970.x

Moosbrugger, H., & Kelava, A. (2012). *Testtheorie und Fragebogenkonstruktion [Test theory and questionnaire construction]*. Berlin, Germany: Springer.

Nair, K. U., & Ramnarayan, S. (2000). Individual differences in need for cognition and complex problem solving. *Journal of Research in Personality*, *34*, 305–328. doi:10.1006/jrpe.1999.2274

Norman, C. D., & Skinner, H. A. (2006). eHealth literacy: Essential skills for consumer health in a networked world. *Journal of Medical Internet Research*, *8*(2), e9. doi:10.2196/jmir.8.2.e9

Pieritz, S. (2017). Die Wirkung positiver vs. negativer Feedbackdarstellungen im Kontext von Gamification [The effect of positive vs. negative feedback presentations in the context of gamification] (Bachelor's thesis). Universität zu Lübeck, Lübeck, Germany.

Potosky, D., & Bobko, P. (2001). A model for predicting computer experience from attitude towards computers. *Journal of Business and Psychology*, *15*, 391–404. doi:10.1023/A:1007866532318

Poynton, T. A. (2005). Computer literacy across the lifespan: A review with implications for educators. *Computers in Human Behavior*, *21*, 861–872. doi:10.1016/j.chb.2004.03.004

Rammstedt, B., & Beierlein, C. (2014). Can't we make it any shorter? The limits of personality assessment and ways to overcome them. *Journal of Individual Differences*, *35*, 212–220. doi:10.1027/1614-0001/a000141

Rammstedt, B., & John, O. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality*, *41*, 203–212. doi:10.1016/j.jrp.2006.02.001

Richter, T., Naumann, J., & Horz, H. (2010). A revised version of the computer literacy inventory (INCOBI-R). *Zeitschrift für Pädagogische Psychologie*, *24*, 23–37. doi:10.1024/1010-0652/a000002

Robertson, I. T. (1985). Human information-processing strategies and style. *Behavior & Information Technology*, *4*, 19–29. doi:10.1080/01449298508901784

Sadowski, C. J., & Cogburn, H. E. (1997). Need for cognition in the Big Five factor structure. *The Journal of Psychology*, *131*, 307–312. doi:10.1080/00223989709603517

Schaarschmidt, M., Ivens, S., Homscheid, D., & Bilo, P. (2015). Crowdsourcing for survey research: Where Amazon mechanical Turks deviates from conventional survey methods (Report No. 1/2015). Koblenz, Germany: Universität Koblenz-Landau.

Schmettow, M., & Drees, M. (2014). What drives the geeks? Linking computer enthusiasm to achievement goals. In *Proceedings of HCI 2014, Southport, UK* (pp. 234–239). doi:10.14236/ewic/hci2014.29

Schmettow, M., Noordzij, M. L., & Mundt, M. (2013). An implicit test of UX: Individuals differ in what they associate with computers. In *CHI '13 2013 ACM SIGCHI on Human Factors in Computing* Systems, Paris, France, April 27–May 2 (pp. 2039–2048). New York, NY: ACM. doi:10.1145/2468356.2468722

Schwarze, D. (2017). Framing-effect and eco-driving: The impact on driving behaviour through different portrayals of eco-indicators (Bachelor's thesis). Universität zu Lübeck, Lübeck, Germany.

Shneiderman, B. (2000). Universal usability. *Communications of the ACM*, *43*(5), 84–91. doi:10.1145/332833.332843

Sicilia, M., Ruiz, S., & Munuera, J. L. (2005). Effects of interactivity in a web site: The moderating effect of need for cognition. *Journal of Advertising*, *34*, 31–44. doi:10.1080/00913367.2005.10639202

Smith, B. N., Kerr, N. A., Markus, M. J., & Stasson, M. F. (2001). Individual differences in social loafing: Need for cognition as a motivator in collective performance. *Group Dynamics: Theory, Research, and Practice*, *5*, 150–158. doi:10.1037/1089-2699.5.2.150

Sojka, J. Z., & Deeter-Schmelz, D. R. (2008). Need for cognition and affective orientation as predictors of sales performance: An investigation of main and interaction effects. *Journal of Business and Psychology*, *22*, 179–190. doi:10.1007/s10869-008-9069-x

Spector, P. E. (1988). Development of the work locus of control scale. *Journal of Occupational and Organizational Psychology*, *61*, 335–340. doi:10.1111/j.2044-8325.1988.tb00470.x

Stöhr, W. (2015). Exploring people's resistance to the active user paradox including personality traits (Bachelor's thesis). University of Twente, Twente, Netherlands.

Timmerman, M. E., & Lorenzo-Seva, U. (2011). Dimensionality assessment of ordered polytomous items with parallel analysis. *Psychological Methods*, *16*, 209–220. doi:10.1037/a0023353

Tyre, M. J., & Orlikowski, W. J. (1996). The episodic process of learning by using. *International Journal of Technology Management*, *11*, 790–798. doi:10.1504/IJTM.1996.025468

Zhang, L.-F., & Sternberg, R. J. (2005). A threefold model of intellectual styles. *Educational Psychological Review*, *17*, 1–53. doi:10.1007/s10648-005-1635-4

Zhang, L.-F., Sternberg, R. J., & Rayner, S. (2012). *Handbook of Intellectual Styles*. New York, NY: Springer.

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Appendix

The English ATI scale and the German ATI Scale

The English ATI Scale

In the following questionnaire, we will ask you about your interaction with technical systems. The term “technical systems” refers to apps and other software applications, as well as entire digital devices (e.g., mobile phone, computer, TV, car navigation).

	Please indicate the degree to which you agree/disagree with the following statements.	Completely disagree	Largely disagree	Slightly disagree	Slightly agree	Largely agree	Completely agree
1	I like to occupy myself in greater detail with technical systems.	□	□	□	□	□	□
2	I like testing the functions of new technical systems.	□	□	□	□	□	□
3	I predominantly deal with technical systems because I have to.	□	□	□	□	□	□
4	When I have a new technical system in front of me, I try it out intensively.	□	□	□	□	□	□
5	I enjoy spending time becoming acquainted with a new technical system.	□	□	□	□	□	□
6	It is enough for me that a technical system works; I don’t care how or why.	□	□	□	□	□	□
7	I try to understand how a technical system exactly works.	□	□	□	□	□	□
8	It is enough for me to know the basic functions of a technical system.	□	□	□	□	□	□
9	I try to make full use of the capabilities of a technical system.	□	□	□	□	□	□

The German ATI Scale

Im Folgenden geht es um Ihre Interaktion mit technischen Systemen. Mit ‚technischen Systemen‘ sind sowohl Apps und andere Software-Anwendungen als auch komplette digitale Geräte (z.B. Handy, Computer, Fernseher, Auto-Navigation) gemeint.

	Bitte geben Sie den Grad Ihrer Zustimmung zu folgenden Aussagen an.	Stimmt gar nicht	Stimmt weit-gehend nicht	Stimmt eher nicht	Stimmt eher	Stimmt weitgehend	Stimmt völlig
1	Ich beschäftige mich gern genauer mit technischen Systemen.	□	□	□	□	□	□
2	Ich probiere gern die Funktionen neuer technischer Systeme aus.	□	□	□	□	□	□
3	In erster Linie beschäftige ich mich mit technischen Systemen, weil ich muss.	□	□	□	□	□	□
4	Wenn ich ein neues technisches System vor mir habe, probiere ich es intensiv aus.	□	□	□	□	□	□
5	Ich verbringe sehr gern Zeit mit dem Kennenlernen eines neuen technischen Systems.	□	□	□	□	□	□
6	Es genügt mir, dass ein technisches System funktioniert, mir ist es egal, wie oder warum.	□	□	□	□	□	□
7	Ich versuche zu verstehen, wie ein technisches System genau funktioniert.	□	□	□	□	□	□
8	Es genügt mir, die Grundfunktionen eines technischen Systems zu kennen.	□	□	□	□	□	□
9	Ich versuche, die Möglichkeiten eines technischen Systems vollständig auszunutzen.	□	□	□	□	□	□