Quantifying Meaningful Interaction: Developing the Eudaimonic Technology Experience Scale

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ABSTRACT

Recent research has shown that users increasingly seek meaning in technologies and that eudaimonic user experience (UX) is part of everyday encounters with technology. Yet, to date, there is no validated means to assess eudaimonic properties in interactive artefacts. We conceptualised, developed and validated a six-item questionnaire for measuring eudaimonic properties of technologies—the Eudaimonic Technology Experience Scale (ETES). Our scale includes two factors, which describe what aspects of a eudaimonic experience can be supported by technology: eudaimonic goals and self-knowlege. We consulted work in Human-Computer Interaction (HCI), psychology and philosophy to gather an initial set of concepts that could contribute to eudaimonic UX. We then built the scale based on expert interviews and exploratory factor analysis and verified its quality in a number of tests (confirmatory factor analysis, reliability and validity checks). ETES provides a standardised tool for identifying eudaimonic qualities in interactive systems and allows for rapidly comparing prototypes.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**.

KEYWORDS

eudaimonia, eudaimonic user experience, scale, questionnaire

DIS '23, July 10–14, 2023, Pittsburgh, PA, USA

ACM ISBN 978-1-4503-9893-0/23/07.
https://doi.org/10.1145/3563657.3596063

ACM Reference Format:
Paweł W. Woźniak, Mitch Hak, Elizaveta Kotova, Jasmin Niess, Marit Bentvelzen, Henrike Weingärtner, Svenja Yvonne Schött, and Jakob Karolus. 2023. Quantifying Meaningful Interaction: Developing the Eudaimonic Technology Experience Scale. In *Designing Interactive Systems Conference (DIS '23), July 10–14, 2023, Pittsburgh, PA, USA.* ACM, New York, NY, USA, 11 pages. https://doi.org/10.1145/3563657.3596063

1 INTRODUCTION

While we used to see interactive technology as merely digital tools to complete pragmatic tasks, digital artefacts now assume a more prominent role in our lives. Earlier work on User Experience (UX) focused on fun and enjoyment (hedonic UX) and more recent work recognised the importance of meaning in using technology (eudaimonic UX) [33]. As our relationships with technology become more and more intimate [48], eudaimonic UX is increasingly important as it may significantly impact the wellbeing of the users. Consequently, a systematic understanding of eudaimonia in technology use is a challenge for Human-Computer Interaction (HCI).

Eudaimonic UX is an established concept in HCI research. The need to design for, understand and evaluate for eudaimonia in interactive systems was postulated by Kamp and Desmet [20]. Mekler and Hornbaek [33] showed that notions of eudaimonic motivation, which had had an established history in Psychology, applied to experiences of interacting with technology. Their insights are primarily based on the notion of eudaimonic wellbeing in the context of orientations, based on Huta and Ryan's work [18]. Huta later developed the HEMA family of scales which allowed for effectively assessing different aspects of eudaimonic motivation. Having recognised that eudaimonic UX is highly relevant to contemporary interactions with technology, the question emerges: how do we design technologies that offer eudaimonic UX? How can we identify designs that possess qualities which foster eudaimonia?

Here, we address these questions by developing a means to identify eudaimonic properties in technologies and compare interactive artefacts in terms of eudaimonia. We follow a structured scale development process [5] to build a reusable tool which will allow for effectively including eudaimonia as part of UX assessment. Our aim is to provide a tool to assess the aspects through which technologies can support eudaimonic experiences. Notably, Mekler and Hornbaek's [33] framing of eudaimonic UX focuses on *long-lasting meaning*, i.e., the temporally prolonged positive impact of using a technology on one's life. Our work extends their view by including pursuit of long-lasting goals as a factor in the scale, but also adding another key aspect of eudaimonia—the pursuit of self-knowledge.

This paper contributes the design, development and validation of the Eudaimonic Technology Experience Scale (ETES)—a scale for assessing eudaimonic UX. We first introduce theoretical considerations which contributed to the initial structure of the scale. Next, we report on expert interviews which informed an initial set of scale items. We then provide the details of the exploratory factor analysis which determined the final form of the scale. The scale was then subject to confirmatory factor analysis, and checks for discriminant, concurrent and temporal validity. Finally, we provide instructions for deploying ETES and discuss its usage in future research and design.

2 RELATED WORK

Eudaimonia is a widely discussed term in Philosophy and Psychology and it has many definitions. In pre-socratic philosophy, *eudaimonism* was understood as the responsibility one has towards one's own personal daimon—an individual's "true self" [23]. The daimon is the manifestation of the individual's innate possibilities to grow and achieve fulfilment, becoming the best version of one's self. According to eudaimonism, individuals have an ethical responsibility to aspire to the higher ideals which their daimon represents. Hedonia is the contrasting concept to eudaimonia. The ethical school of hedonism founded by Aristippus of Cyrene used pleasure, or hedonia, as a foundation for its ethical system. Hedonists see pleasure as the highest achievable goal. In hedonistic schools of thought, pleasure is seen as the only good in life; pain being the sole evil [49]. A good and happy life thus consists of maximising pleasurable experiences and minimising painful experiences. The ethical value of an action is thus determined by whether the behaviour is aimed towards the expansion of pleasure and the diminution of suffering.

Aristotle refuted the hedonic ideal in his Nicomachean Ethics, calling it a vulgar ideal that makes mankind slaves to their desires and appetites [2]. Instead, he advocated that the highest pursuit in life is eudaimonia, his concept of "the good life". To be eudaimonic is not to follow one's desires, but to act virtuously and in accordance with one's daimon. As posed by Telfer [49], eudaimonia is not being pleased with what one has achieved in life, but with "what is worth desiring and worth having in life". Waterman [52] argues that eudaimonia is necessarily connected to a strong value system. The things in life that are worth pursuing, for example acting virtuously, can be considered universal and valid for all humans. Hedonic enjoyment, on the other hand, is arguably rooted in subjectivity: what is considered pleasurable for one might not be pleasurable for the other.

This philosophical dilemma of pursuing "the good life" is still relevant today and almost unavoidable in everyday life. Thus, eudaimonia and hedonia are also of interest to designers and researchers seeking to understand the everyday use of technology. Our work helps apply the concept of eudaimonia in the task of designing interactive technologies. In this section, we first show how eudaimonia was conceptualised in psychology and how that understanding can inform HCI. Next, we review past work of eudaimonia in UX. Finally, we discuss past results in measuring eudaimonia, oustide of the context of technology use.

2.1 Eudaimonia and Wellbeing

Research in psychology recognised the role of eudaimonia as a factor contributing to an individual's wellbeing. The perspective of eudaimonia considers aspects of wellbeing beyond happiness (or subjective wellbeing [11]). Ryan and Deci's [41] research indicated that a perception of happiness (i.e., a feeling of satisfaction or positive affects) must not necessarily result in psychological wellbeing. Ryff's [43] theory of psychological functioning, argues for an approach that measures wellbeing and optimal human functioning instead of self-reported happiness. Theories like these resemble the philosophical eudaimonic approach: not seeing happiness and wellbeing as mere pleasure, but as striving for virtuous and healthy ideals. Waterman [52] noted that eudaimonia was a key concept for positive psychology. He showed that, although the experiences of hedonic enjoyment and personal expressiveness correlate strongly, they each contain unique and distinguishable facets [54].

Another strain of work explored eudaimonia and hedonia as motives for activities and behaviour rather than experiences in and of themselves. Huta and Ryan [18] found that eudaimonic and hedonic pursuits related closely to vitality and life satisfaction. However, both concepts do have their own distinct properties: eudaimonia was more closely correlated with meaning and elevating experience; hedonia strongly related to carefreeness and showed stronger links with positive affect than eudaimonia. Notably, hedonic motives showed improved immediate wellbeing while eudaimonic motives for behaviour led to better results after three months. This is in line with findings that suggest that meaning, a core ingredient of eudaimonic motives, is something which develops over time [3, 21]. These works show that research in psychology established that eudaimonia is a key component for wellbeing. Given that designing technologies that support wellbeing is a recognised design goal for interactive technologies [45], HCI developed an interest in eudaimonia, including its conceptualisations in user experience. Our work explores the means to systematically use eudaimonia and design wellbeing technologies more effectively.

2.2 Eudaimonic UX

HCI made significant efforts in adapting psychological work on eudaimonia and employing these insights to design interactive technologies. Desmet and Hassenzahl [9] discussed the role of the eudaimonic–hedonic distinction in HCI. They noted that technology could directly improve happiness and wellbeing through what they coined as possibility-driven design, shifting the paradigm of design in HCI from problem-solving to designing for wellbeing and happiness. To that end, Diefenbach et al. [10] proposed to draw knowledge from the behavioural and social sciences; mainly from research on happiness and wellbeing.

Recognising the role of eudaimonia in user experience leads to the question of what attributes of an artefact make it eudaimonic. The hedonic–pragmatic dichotomy of attributes for a positive user experience was successfully employed in many research efforts in HCI [13, 15]. Pragmatic attributes are associated with the task to be preformed using a system. Hedonic product qualities focus on product attributes that bring about positive experiences and perceptions. These attributes are usually self-referential and contain a judgement of sorts towards the product on whether the users' needs are fulfilled [14]. Kamp & Desmet [20] proposed a third category: eudaimonics. These attributes are hypothesised to contribute to meaningful, longer-term goals. This approach, i.e., focus on long-term meaning, was later adopted by Mekler and Hornbaek [33] to highlight the need for technologies to support long-term meaning-making.

We pose that designing interactive artefacts for wellbeing is not necessarily opposed to the utilitarian view of HCI as problem solving [37]. As suggested by Mekler and Hornbaek [33], integrating eudaimonia as part of the design process can assure that eudaimonic properties are embedded in the properties of interactive artefacts. Further, we note that interactive technologies are unlikely to be eudaimonic *per se*, just like they cannot be intrinsically pragmatic or hedonic. Instead, eudaimonic experience can be supported through careful design for eudaimonia, similarly to how pragmatic experience is supported by design for usability. This work aims to give researchers and designers a richer set of tools to support design processes that include eudaimonic experience.

2.3 Measuring Eudaimonia

The prominent use of eudaimonia in psychology resulted in a number of measurement instruments being developed to quantify eudaimonic experiences. Notably, Huta (in a number of collaborations) developed the HEMA family of scales, which address eudaimonic motives behind one's action. The original HEMA scale [18] was a 9-item questionnaire, which was later refined as the HEMA-R [16] and extended to include an optional hedonic comfort component. The HEEMA [24] is a longer version of the questionnaire which offers a distinction between hedonic pleasure and hedonic comfort. Earlier research also contributed scales which measure concepts which are (partly) linked to eudaimonia such as positive affect (the PANAS scale [8]). Waterman [53] operationalised happiness as having hedonic and eudaimonic factors. While these instruments have been extensively validated, they measure motivations, orientations and affective states. It remains a challenge to relate these concepts to experiences of interactive technology. A key motivation for our work is the fact that, to our knowledge, no scale for measuring eudaimonia was validated for studying experiences of technology. Further, there are currently no tools that would enable exploring what design properties of interactive systems can support the pursuit of eudaimonia. Our work provides a first step for that investigation by introducing the means to determine which designs support eudaimonia more or less effectively than other designs.

Within HCI, Mekler and Hornbaek [33] applied the HEMA to understand the motivations behind using technology. We note that their study investigated why participants used particular technologies and not the properties of the technology. As Mekler and Hornbaek [33] provide clear evidence that users pursue eudaimonic goals and perceive meaning through the use of technology, the logical next step for HCI is to understand what properties of interactive technologies can support eudaimonia. This work explores the ways in which we can measure a technology's degree of support for eudaimonia. We posit that an affective tool for rapidly assessing eudaimonic properties of technologies will not only allow for assessing whether or not technologies can support eudaimonia but also facilitate designing new technologies with eudaimonic needs as a design goal.

3 OPERATIONALISING EUDAIMONIC UX: CONCEPTUAL MODEL

Designing scale for measuring the eudaimonic aspect of the experience of interactive technologies requires recognising that any such experience must be driven by eudaimonic motives. That is, a eudaimonic motive is a prerequisite to eudaimonic experience. If a user engages in using a technology driven by eudaimonic motives, eudaimonic UX can be enacted. The focus of our work is not conceptualising the experience of eudaimonia itself, which was achieved by past research in psychology, but to quantify the design qualities of technology that facilitate the enactment of eudaimonic UX. The first step in developing a scale is assuming a theoretical model which describes the measured concept. Here, we propose an operationalised understanding of eudaimonic UX based on our reading of related work in HCI and the underlying theory in the humanities.

The theoretical departure point for our inquiry is the collection of eudaimonic motives as they are the most studied aspect of eudaimonia. A systematic review by Huta and Waterman [19] showed that there were four elements included in most definitions of eudaimonia: authenticity, excellence, growth, and meaning. These concepts are assessments of oneself and potential pursuits. We note that the elaboration of these four concepts took extensive research in psychology and the limits of their application to experiences of technology would require a similar effort. Thus, there is a need for a less complex concept of eudaimonia that would enable assessing eudaimonic UX. While applying Huta and Waterman's four elements of eudaimonia to interactions with technology would be an analytically appealing approach, we recognise that technology can only evoke of subset of experiences considered in the original study. Thus, eudaimonic experience of technology should be a narrower concept. Given that character features may not be salient when thinking of technologies and considering Mekler and Hornbaek's [33] results which showed that long-term use is likely to be associated with eudaimonia in technology use, we operationalise the ways in which technology can support eudaimonia in two dimensions. These dimensions represent two eudaimonic pursuits: eudaimonic goals and self-knowledge. The two dimensions represent our proposed conceptual model of eudaimonic UX. We chose the dimensions so that they describe the potential experience of eudaimonia in a broad sense and can be used as design goals for

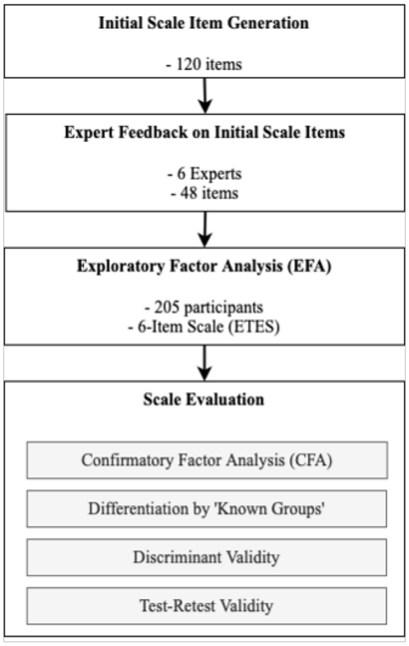

Figure 1: The scale formation process consisted of four phases: (1) the initial generation of scale items, (2) expert feedback, (3) Exploratory Factor Analysis, and (4) the evaluation of the scale.

future technologies. Further, the proposed model spans a broad temporal spectrum as it includes both the notion of supporting future eudaimonia and immediate eudaimonic experiences.

The concept of *supporting the pursuit eudaimonic goals* embraces the long-term orientation involved in using technology driven by eudaimonic motives. This category also includes uses of technology 'for the greater good' and eudaimonic pursuits connected to serving ideals, social groups or the society [42].

Providing *support for self-knowledge* describes properties of technologies that allow the user to be in touch with their 'true self'. Here, we recognise the potential of technologies to foster authenticity and growth. In line with Schlegel et al. [44], we include self-knowledge as the source of meaning and value in eudaimonic experiences.

4 SCALE DEVELOPMENT

Having conceptualised a possible model for eudaimonic UX, we decided to develop a scale that would verify our concept and allow for assessing support for eudaimonia in interactive technologies. Boateng et al. [5] describe a set of best practices in developing scales and our process adhered to the range of methods described in their work. Figure 1 shows the structured process of developing ETES—the Eudaimonic Technology Experience Scale. The process follows similar scale development studies in HCI, e.g. [4, 32, 55]. For details on the interpretation of individual reported parameters, we refer the reader to method-specific references provided by Boateng et al. [5]. Next, we provide the details of all the stages of the scale development.

4.1 Initial Scale Item Generation

Based on our operationalisation of eudaimonic UX, two researchers generated a list of candidate scale items. We created custom scales and rephrased items from other scales (HEMA, PEAQ) so that they would describe experiences of technology. This was achieved in an iterative process which involved two authors. We iteratively refined the generated list of initial items, ensuring that the items were in line with our literature study of concepts of eudaimonia, i.e. we applied the deductive method [5]. We also included items which addressed properties of interactive artefacts which were noted to be related to eudaimonic UX [34, 35]. Additionally, we generated reverse-scored items to control for agreement bias. The item generation process resulted in a set of 120 initial items, which were then subject to further analysis. The initial items are available in the auxiliary material.

4.2 Expert Feedback on Initial Scale Items

The initial item pool was then reduced through expert reviews. We recruited six research experts by contacting authors of papers on eudaimonic motives and eudaimonic UX by e-mail. We identified researchers interested in eudaimonic UX (as evidence by their publications in the area) as key future audience for the scale who should partake in scale devlopment as experts [5]. Table 1 presents the fields of expertise of the experts and the outcomes of their feedback on the initial item list. Given that the notion of eudaimonic UX has received limited attention to date, we do not reveal demographic information about the experts as it would make it likely that they would be identified (the survey was completed anonymously). The experts were presented with an operational definition of eudaimonia in technology use to aid their assessment of the items: *The orientations, experiences and improvement of psychological functioning related to personal growth, authenticity, meaning and excellence, which arise through the use of interactive technology.*

We asked the experts to rate each of the items using a four-point Likert scale, which avoids the neutral midpoint as suggested by Lynn [27]. We then used the I-CVI index developed by Polit and Beck [38] to identify relevant items. This method implies computing a quotient for the share of experts who ranked the item with 3 or 4. For six or more judges, a value of $I\text{-}CVI > 0.78$ is required for an item to be judged as relevant and we used that as a threshold value for items to be included in the survey. The experts also suggested phrasing and grammar corrections to some of the items and the suggestions were implemented. This process resulted in a set of 48 items which were used in the further development of ETES. The reduced item set is available in the auxiliary material.

4.3 Exploratory Factor Analysis

Next, we administered the initial survey to a large set of participants to conduct exploratory factor analysis (EFA). We used the Qualtrics online survey tool to deploy the questionnaire. The survey asked for relating one's experiences of using a smartphone to each of the items in the item list.

We recruited a total of 205 participants, 93 males, 105 female and 7 non-binary (no participants chose to not disclose or self-describe gender). Participants were distributed in age ($18 - 65\,y$) and were mainly students or full-time employees. In this phase, our

Expert No.	Field of expertise	Items rated 'relevant' (3 or 4)
1	User Experience	78
2	Media Psychology	46
3	Positive Psychology	77
4	User Experience	79
5	Design for Well-Being	85
6	Media Psychology and Communication	52

Table 1: Panel of experts with their fields of expertise and item ratings. The expertise presented was self-declared by the experts.

recruitment strategy included snowball sampling through social media posts. Participants were primarily residents of the European Union and the USA. This is due to the fact that most studies in personal informatics and studies underlying theories which inspired the scale were conducted on Western samples. Boateng et al. [5] note that a sample size of 200-300 is appropriate in scale development of this type. We note that local scale development sample size standards in HCI are not established. Thus, we ensured that all sample sizes in this work conform to Boateng et al. [5]'s recommendations, while exact numbers of participants were determined by the number of discarded incomplete answers. We refer readers to the supplementary material for the full data set and analysis.

We conducted Exploratory Factor Analysis using the Varimax rotation on the 48 items in the survey. This method was previously used to develop scales in HCI [32, 55]. We assumed that eudaimonia would be determined by independent components and thus used an orthogonal rotation. Based on visually analysing scree plots, we decided that a two-factor model would be most appropriate. We then conducted item reduction.

We closely followed the procedure prescribed by Boateng et al. [5], first removing all item loadings below 0.30. We then removed items that loaded on both factors. This resulted in a list of eligible candidate items which could contribute to the scale. Next, we decided to optimise for the length of the scale. A rapid assessment instrument would be preferable in our case, given that we envisioned that the ETES would be used in user studies of technology use. Most sources agree that the minimum number of items in a scale factor should be three with only a few exceptions [5]. Consequently, we chose the three top-loading items from each of the factors. We then computed Cronbach's alpha coefficients and computed the factor model based on those items. All parameters were satisfactory, including Cronbach's $\alpha > 0.70$ for the scale and both factors. Theoretical factor model fit parameters also fulfilled the criteria provided by Boateng et al. [5]: $RMSEA = 0.013$, $TLI = 0.999$. The theoretical model explained 60% of variance and item communalities were sufficient (> 0.60) [28].

4.3.1 The Resulting Scale. At this stage, our analysis resulted in a theoretical scale structure and an underlying theoretical model. Before progressing to verify the model and assuring the reliability of the scale, we provide a full specification of the items in the scale. Table 2 shows the six items which contribute to the two scale factors. The scope of the items and their theoretical statistical relations reflect our two-factor conceptual model where ETES consists of the two factors: ETES-EG—(supporting the pursuit of) eudaimonic goals and ETES-SK—(supporting the pursuit of) self-knowledge.

4.4 Scale Evaluation

In the next stage of our process, we evaluated ETES in order to establish its quality and robustness.

4.4.1 Confirmatory Factor Analysis. To verify if the theoretical model and the corresponding scale structure were valid, we conducted Confirmatory Factor Analysis (CFA). To that end, we designed and deployed another survey in Qualtrics. We recruited 251 participants via Amazon Mechanical Turk (MTurk). The participants resided in the United States or the European Union. We required participants to have completed at least 1,000 HITs with a 95% acceptance rate, in line with past studies, e.g. [12]. Mturk was previously used in scale development in HCI [4] and thus represents a versatile and effective recruitment tool. This choice assured that we used a variety of recruitment sources in the study. The participants were aged $20 - 69$; 156 were male, 93 female, 1 non-binary and 1 preferred not to answer. We remunerated the participants with USD 1 for an average of 3.4 min of survey completion time. The survey asked participants to rate their anticipated experience of a prototype of a hypothetical meditation app as shown in Figure 2. We used this example as experiences of meditation and mental wellbeing are associated with eudaimonia, as previous work connected mental self-care practices, like meditation to eudaimonic experiences [1, 6]. Further, the prototypes used in this step are in line with our envisioned future use of the scale in a user-centred design process—comparing prototypes of technologies in terms of how users perceived them as offering an experience of eudaimonia and the concept has peen primarily discussed in the context of wellbeing [25].

Our analysis resulted in a model which satisfied the criteria mentioned by Boateng et al. [5]. We obtained a Tucker Lewis Index of factoring reliability, $TLU = 0.992$ and $RMSEA = 0.028$. These results indicate that the factors of our theoretical model were validated and the ETES scale could be subject to further checks as it was internally consistent. Moderate to high correlations between the items and the scale factors provide additional evidence of the validity of the model as shown in Figure 3.

Cronbach's Alpha. Using the data obtained in the CFA survey, we calculated Cronbach's alpha for the full scale and the scale factors to check for inter-item reliability. Boateng et al. [5] concludes that this measure is the most commonly used means of assessing the internal consistency of the scale items. The results showed acceptable Cronbach's alpha levels. ETES: $\alpha = 0.75$; ETES-EG: $\alpha = 0.70$; ETES-SK: $\alpha = 0.78$. This indicates that the ETES is internally consistent.

Table 2: The ETES is a six-item instrument consisting of two dimensions

The Eudaimonic Technology Experience Scale, $\alpha = 0.82$	
Subscale/Item	**Factor Loading**
Eudaimonic goals, $\alpha = 0.82$	
Q1: I used this system to learn new things	0.61
Q2: I used this system to pursue my aspirations	0.83
Q3: This system stimulated me to pursue my goals	0.53
Self-knowledge, $\alpha = 0.74$	
Q4: When using this system, I felt a connection with my deepest feelings	0.64
Q5: When using this system, I felt like I was in touch with who I truly am	0.79
Q6: When using this system, I felt that my choices expressed my 'true self'	0.77

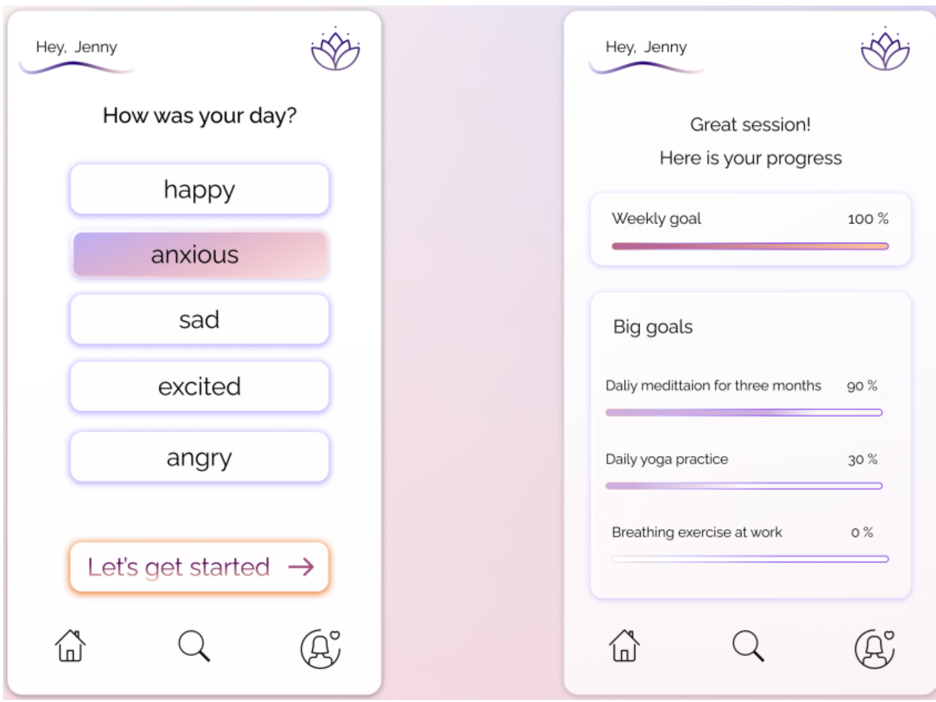

Figure 2: The meditation app prototype used in the CFA survey. Users were asked to rank their perception of the prototype on the ETES.

4.4.2 Differentiation Between 'Known Groups'. The last stage in the process of developing ETES consisted of two validity checks. First, we established the scale's ability to distinguish between different levels of support for the pursuit of eudaimonia through comparison between 'known groups'. Then, we examined discriminant validity of the ETES, i.e., we checked if it measured concepts different than existing scales.

Both validity checks were performed in a single survey. We used MTurk to recruit 56 participants, aged 24–53, 39 male, 17 female. We used the same eligibility criteria as in the CFA survey and the participants received USD 1.20 as remuneration for completing the survey which lasted an average of $9min : 42s$. The survey consisted of two examples of mobile apps, one designed to support eudaimonia (through encouraging meditation) and one designed to support hedonia (by trying to persuade the user to eat a cookie). We used this contrast to simulate a situation where a prototype of an interactive technology would exhibit significantly higher levels of support for eudaimonia than another prototype. The prototypes are shown in Figure 4. Participants were asked to rate both prototypes using ETES, the PANAS [8], HEMA [18], and AtrakDiff (English version) [15]. We chose those scales as we wanted to investigate if ETES may be measuring affect (PANAS), or hedonic/pragmatic user experience (AttrakDiff). We also included the HEMA to investigate the relationship between ETES scores and eudaimonic orientation.

Comparing two conditions where one would expect to see a significant difference was often used as part of scale building in

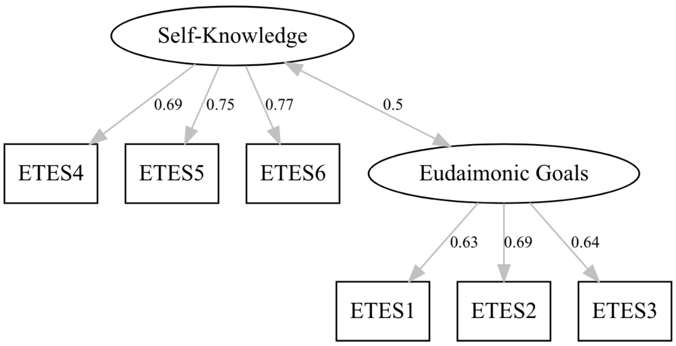

Figure 3: The resulting model for the ETES after confirmatory factor analysis. The scale consists of two factors with three items each.

	COOKIE		MEDITATION			
	M	*SD*	*M*	*SD*	*W*	*p*
ETES	21.09	2.97	23.12	4.00	1129.5	< .05
ETES-EG	10.49	2.66	11.51	2.20	1153.0	< .05
ETES-SK	10.60	2.64	11.62	2.18	1154.5	< .05

Table 3: Results of tests for differentiation between known groups. Wilcoxon signed-rank test scores (W) showed that the ETES scores were significantly different between the COOKIE and MEDITATION conditions.

HCI [32, 55]. Comparison between 'known groups' involves comparing two conditions were one would expect to obtain significantly different results in scale measurements. [5]. We decided to apply a similar procedure to show that ETES can be effectively used to compare two interactive artefacts. In our survey, we compared the hedonic condition (persuading to eat a COOKIE) to the eudaimonic condition (suggesting MEDITATION). Importantly, given that no prior measurements of eudaimonic UX exist, we cannot assume that any of the conditions would achieve high scores for eudaimonia. However, given the high association of food consumption with hedonic motives [51], one can expect that eudaimonic experience would be less present in the COOKIE condition. Similarly to past HCI work, we use non-parametric tests to investigate the differences as the exact statistical properties of the new scale require further use in studies. Using Wilcoxon signed-rank tests (as our survey was a within-subjects design), we found that there was as a significant effect of the condition on ETES scores and the individual factor scores. The results are shown in Table 3.

4.4.3 Discriminant Validity. Next, we investigated whether ETES was related to other scales and sought to check if our scale was not measuring established concepts with new items. It was theoretically possible that high ETES scores could be a reflection of a perception of usability or strictly determined by eudaimonic orientation. Thus, we identified positive and negative affect (PANAS-P and PANAS-N), hedonic and pragmatic qualities of user experience (AttrakDiff, AT-H, AT-P), and hedonic and eudaimonic orientation (HEMA-H, HEMA-E). We then computed Spearman correlation coefficients

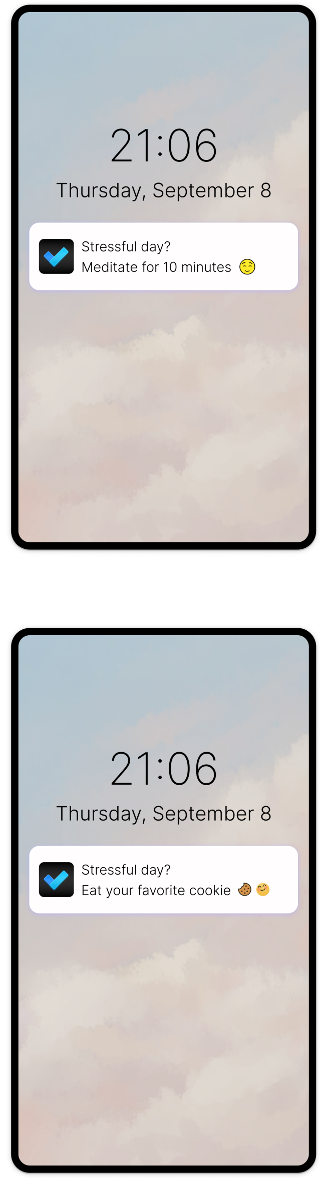

Figure 4: Two prototypes used as examples of interactive technologies for the validity check. The MEDITATION condition (left) was designed to support eudaimonia and the COOKIE condition (right) supported the pursuit of hedonia.

between the results obtained for the potentially related scales and ETES and its two factors. The results are presented in Table 4.

The results show at most moderate correlations with other measures [7]. The highest correlation coefficients were obtained for HEMA-E. This indicates that there may be evidence in our study for eudaimonic experiences of technology being affected by eudaimonic orientations. This confirms past results that the pursuit

	ETES	ETES-EG	ETES-SK	HEMA-H	HEMA-E	PANAS-P	PANAS-N	AT-H
ETES	1							
ETES-EG	0.88*	1						
ETES-SK	0.88*	0.59*	1					
HEMA-H	0.46*	0.39*	0.47*	1				
HEMA-E	0.64*	0.54*	0.62*	0.64*	1			
PANAS-P	0.59*	0.58*	0.54*	0.32*	0.45*	1		
PANAS-N	-0.09	-0.12	-0.15	-0.12	-0.01	0.23	1	
AT-H	0.43*	0.40*	0.40*	0.31*	0.27	0.14*	-0.58*	1
AT-P	0.32*	0.37*	0.26	0.26	0.22	0.10	-0.70*	0.69*

Table 4: Results of Spearman correlations for the scales which we tested to establish the concurrent validity of ETES. Significant correlations, $p < .05$ were marked with *.

of eudaimonia—individuals inclined towards eudaimonia will seek such experiences more actively [17]. We also note a moderate correlation with PANAS-P, which can be explained by the fact that (the prospect of) a eudaimonic experience is likely to produce a positive affective response [29]. Yet, we can conclude that the ETES, besides using items that allow for evaluating systems, measures a different concept than HEMA-E. Correlations to other scales were weak or moderate [7], indicating a weak relationship between ETES and the examined concepts. The results show that ETES has discriminant validity.

4.4.4 Test-retest reliability. Subsequently, we evaluated the temporal stability of ETES, i.e., we checked whether scores obtained using the ETES at different points in time are consistent. There is no consensus over what time should elapse between the two measurement moments for measuring test-retest reliability in scales which apply to interactive technology. In HCI, Woźniak et al. [55] used a 14-day period, while, in other fields, such periods vary. Marx et al. [30] found that there was no significant difference between using a period of two days and two weeks. In our study, we used a period of 12 days or more, which allowed for effective recruitment and re-recruitment while not compromising validity.

We recruited 30 participants through snowball sampling on campus. A second method of recruitment contibuted to the driverusty of the sample used in scale development. The participants were aged 20–55; 14 male, 16 female. The participants were asked to complete the same tasks as in the CFA survey and the responses were gathered using Qualtrics.

Similarly to Woźniak et al. [55], we used the intra-class correlation coefficient, as suggested by Koo and Li [22], to measure test-retest reliability. We obtained moderate and substantial [46] reliability for the full scale and the two factors. ETES: $\kappa = 0.90$, $p < .001$; ETES-EG: $\kappa = 0.90$, $p < .001$; ETES-SK: $\kappa = 0.78$, $p < .001$. These results indicate that ETES scores remain stable over time.

5 USING THE EUDAIMONIC TECHNOLOGY EXPERIENCE SCALE (ETES)

The ETES consists of two factors and six items. Each item is to be scored on a five-point Likert scale, from 'strongly disagree' to 'strongly agree'. In the surveys, we introduce the ETES with the instructions: *'Please rate your agreement with the following statements'*. Each time, the representation of the system was placed directly above the sentence to ensure that the participants think of the system to be assessed while rating the items. All items of the ETES feature the words 'the system' which further directs the attention of the participant to the interactive artefact at hand. We anticipate that further usage of the scale may result in substituting the words 'the system' with the name of the interactive technology studied. This may, however, require additional validation of the scale.

Simple scoring is an advantage of the ETES. All reverse-scored items were discarded during item reduction and thus the score for each of the factors is a simple sum of the scores of the contributing items. The lowest possible score on the scale is 6 and the highest is 30. Consequently, ETES is scored as follows:

$$ETES = ETES\text{-}EG + ETES\text{-}SK$$
$$where\ ETES\text{-}EG = ETES1 + ETES2 + ETES3$$
$$and\ ETES\text{-}SK = ETES4 + ETES5 + ETES6$$

The higher the ETES score, the more support a given interactive technology provides for eudaimonic experience. Given that we conducted a structured scale development process, ETES possesses the necessary qualities to enable statistical testing on ETES scores. We hope that future studies in HCI will use the ETES and its properties will become better known. For the time being, we suggest a conservative approach and comparing ETES scores using non-parametric tests.

6 DISCUSSION

Here, we first discuss suggested applications of the ETES and the ways in which ETES can contribute to studies in HCI. We then discuss the limitations of our approach.

6.1 Potential Uses for the ETES

The development and validation of the ETES indicates that it can be used as a robust instrument in HCI studies. The key advantage of ETES over past scales, e.g. HEMA is its core focus on experiences of technology and the fact that our study validated the scale for use in a technology context. We envision that the ETES can be particularly suited for comparisons, especially at early stages of its use. If eudaimonic experience is a desired quality in a given design, ETES offers a rapid way to identify more optimal versions of the design. Further, the relatively short ETES survey form makes it feasible to rapidly screen prototypes using ETES. Comparing interactive artefacts with ETES should be effective irrespective of the fact that the interpretation of single ETES scores requires further research.

As a fully validated scale, the ETES can be used in a variety of HCI studies that feature different experimental designs. Yet, recognising the complexity of the concepts behind eudaimonia, we recommend using ETES primarily in mixed-method studies where the use of the scale is accompanied by qualitative data gathering. Additional data sources can not only help ensure that one can identify which aspects of a design contribute to a perception of eudaimonic experience but also allow for understanding the motivations behind eudaimonic use of technology. We also note that eudaimonia can be a trait [19] and the HEMA scales provide the means of measuring trait eudaimonic orientation. This may be of particular importance in studies where one would study changes in ETES scores over a period of time. In such a case, we recommend using trait eudaimonic orientation measured before the study as part of the analysis model.

6.2 Potential Application Domains

While eudaimonia may be part of many research agendas in HCI, eudaimonic experience was often linked to designing technologies for wellbeing [34]. Consequently, ETES is likely to be used in the evaluation of technologies that support wellbeing. Technologies for mindfulness have recently received increased attention and their evaluation still remains a challenge [25, 50]. Experiences of mindfulness are linked to eudaimonic experiences and we hope that ETES can help broaden the understanding of designing for mindfulness. Here, we hypothesise that conducting analyses on ETES-SK may be of particular use as eudaimonic goals related to self-discovery were previously linked to using technology for wellbeing [36].

HCI also has an interest in understanding the experience of meaning in general technology use [26, 33]. ETES was designed as a technology-agnostic scale and can thus help in such investigation. Consequently, we hope that our scale can help in building an understanding which experiences of technology which may include eudaimonic UX.

6.3 Limitations

We note that the development of ETES required a number of design decisions and conceptual choices which determine the scale's scope of application. First, we recognise that while psychology devoted significant research effort to understanding eudaimonia, the concept is not fully understood. The relationship between the use of technology and experiences of eudaimonia also requires further investigation. Thus, ETES measures anticipated experiences of eudaimonia, manifested through qualities of an interactive artefact. Consequently, given current concepts of eudaimonia it is not possible for ETES to measure 'true' eudaimonic UX, but only its traces observable by support for eudaimonic goals and self-knowledge.

Second, one can observe that the expert reviews resulted in a large reduction of the number of items, despite the fact that items were generated based on existing concepts of eudaimonia. This suggests that many of the ways in which eudaimonia can be conceptualised as part of happiness or in terms of orientations were not perceived as applicable to experiences of technology. Given that eudaimonia is originally a quality associated with spiritual life [2], the primarily task-oriented activity of using technology can only address parts of eudaimonic experience. We hypothesise that technology has not 'weaved in' (cf. [40]) into everyday lives to encompass all aspects of eudaimonic experience and, thus, experiences of technology represent a relatively small subset of eudaimonic experiences. For example, the role and scope of technology in spirituality remains largely unexplored [39].

For that reason, from the start of our scale development process, we assumed that the factor structure of ETES would not be complex. One could assume that measuring hedonic experiences of technology would follow the four-factor structure of pursuits as suggested by Huta and Waterman [19]: authenticity, excellence, growth, and meaning and thus result in a model with four factors. We were opposed to that assumption as it would also include an assumption of a dystopian technology-saturated reality. Our statistical analysis found no evidence for the existence of four latent variables in the survey data. On the one hand, the two-factor ETES can be rapidly deployed and easily scored. On the other, a more elaborate scale with more factors could facilitate identifying design qualities of interactive technology which support eudaimonia more precisely.

Finally, we remark that despite using a variety of recruiting strategies in developing ETES, our sample consisted primarily of WEIRD [47] participants recruited in Western cultures. Eudaimonia is a culturally situated concept [31] and further studies are required to understand the applicability of ETES across cultural contexts.

7 CONCLUSION

This paper described the theoretical underpinnings, development and validation of the ETES—the Eudaimonic Technology Experience Scale. We first discussed the use of eudaimonia in HCI and other fields to develop an initial conceptual model of eudaimonic UX. We then developed the ETES in a process involving expert reviews, exploratory and confirmatory factor analysis, tests of reliability and validity checks. Our scale construction process assures the validity necessary for the instrument to be used in further studies. We hope that ETES will facilitate the inclusion of eudaimonia as part of evaluating systems as well as using eudaimonic experience as a design goal for future technologies.

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